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PATENT

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In re: Tupman et al. Confirmation No.: 8775
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Filed: January 20, 2004
For: GOLF STROKE TRAINING DEVICE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUBMITTAL OF PRIORITY DOCUMENT

To complete the requirements of 35 U.S.C. § 119, enclosed is a certified copy of United Kingdom priority Application No. 0301360.4, filed January 21, 2003.

Respectfully submitted,

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JRJC/CLL/39373

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21 JAN 2003

3. Full name, address and postcode of the or of each applicant (underline all surnames)

SCRATCH LTD

Patents ADP number (if you know it)

Ashcroft Cameron (Scotland) Ltd
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If the applicant is a corporate body, give the country/state of its incorporation

UNITED KINGDOM

0301360.4

4. Title of the invention

GOLF STROKE TRAINING DEVICE

5. Name of your agent (if you have one)

fJ Cleveland

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

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Country

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Date

21 January 2003

12. Name and daytime telephone number of person to contact in the United Kingdom

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Golf Stroke Training Device

The present invention relates to a golf stroke training device for assisting an individual in practising a golf stroke. In particular, the invention relates to a device for assisting a golfer in practising a putting stroke.

5 An important aspect of a golfer's game is the ability to putt a golf ball accurately into the cup of a hole on a golf course. Although simple in concept, it is actually difficult to master and maintain a proper putting technique. There are a variety of errors that can occur from the time a golfer addresses the ball on a green right through to the point at which the golfer makes contact with the ball. Correcting any such errors requires a golfer to practise
10 repeatedly his or her stroke in order to develop a feel for a proper, effective stroke. It is therefore desirable to have a practice aid that enables a golfer repeatedly to practise their putting stroke, whilst providing a degree of feedback to the golfer which will allow them to develop a feel for the stroke which can be quickly and successfully transferred to their actual game. Furthermore, as conditions on different putting greens vary, i.e. the greens
15 may be of different "speeds" or have varying contours or undulations, it is also desirable to have a practice aid which can simulate conditions on a variety of putting greens.

 WO-A-009216 discloses a golf putting training device, developed to aid a golfer in practising their putting stroke. The device includes a user interface for allowing a user to pre-select a putting green speed, or "stimp value", before making a practice putt. The
20 device also includes a target mounted at an end of a shaft, which target rotates in a vertical plane about a central fixing of the shaft when struck by a user. Using the pre-selected stimp value, and the initial angular velocity of the target, which is calculated by a putting force sensor, a microprocessor of the device is able to determine the notional distance of the putt made by a user. A problem of using this device is that the resistance to the motion of the
25 ball is always the same from the moment the ball is struck. Thus, the device does not allow

a golfer to develop a feel for putting a golf ball on surfaces of varying frictional resistances.

GB-B-2316010 discloses a golf training device, developed to aid a golfer in practising their iron shots. The device includes a golf ball which is tethered by a flexible
5 cord to a wheel which is mounted for rotation in a horizontal plane. A user makes a pre-shot club selection in order to communicate to the device which club he is using. The ball is then placed on the ground, or on a golf tee, before the user plays his stroke. The wheel to which the ball is tethered carries on its upper surface an optical ring having a number of equally-spaced fingers which project from its upper surface. A photo-emitter
10 and opposing photo-receiver are arranged on opposite sides of the ring so when the ball is struck, and the wheel and ring arrangement thereby caused to rotate, the fingers of the ring intermittently interrupt a beam of light emitted by the photo-emitter, so that the photo-detector detects a series of pulses of light, each pulse comprising light from the photo-emitter which has penetrated a gap provided between adjacent fingers of the wheel.
15 By counting the number of light pulses detected in a predetermined period of time, the device is able to calculate the initial velocity of the target, and by comparing this with pre-programmed data for the specific club used, is able to derive a notional distance which the ball would have travelled if it had not been tethered. The notional distance is communicated to the user by a display unit which is mounted on the device. A
20 disadvantage of this device is that it cannot be used for practising putting strokes because the ball's movement along the floor would be impaired by the flexible cord which attaches it to the device. Furthermore, the device cannot provide a visual, real-time indication of how far the ball would have travelled had it been free, rather than tethered.

It is an object of the invention to provide an improved training device to assist a
25 golfer in improving their putting technique.

It is a further object of the invention to provide a training device that accurately simulates the feel of putting on surfaces of different frictional resistances, and which is able to provide a visual, real-time indication of the distance that a free ball would have travelled on a putting green.

5 According to one aspect of the invention therefore there is provided a golf stroke practising aid comprising: a target adapted to be struck by a golf-club; guiding means for constraining said target to move in a substantially horizontal orbit when struck; measuring means for measuring the initial speed of the target when struck; processing means configured to determine a notional total distance that the target should travel in its orbit
10 corresponding to said initial speed; and motion controlling means adapted to control the movement of the target in its orbit when struck such that the target actually moves a total distance which is substantially the same as said notional total distance. An advantage of using such a device is that it allows a user to observe the motion of the target after it has been struck and to develop an awareness of exactly how far the ball has travelled.

15 The notional total distance may be the total distance that a standard golf ball would have travelled freely on a real putting green.

In some embodiments, the processing means are adapted to calculate a notional relationship between the instantaneous speed of the target and the elapsed time after striking said target based on said notional total distance, said measuring means are adapted
20 to measure continually the elapsed time after striking the target and the actual instantaneous speed of the target as it moves in said orbit, and said motion controlling means are adapted to compare the actual instantaneous speed with said notional instantaneous speed and to adjust continually the speed of the target accordingly to ensure that the target moves about said total distance.

The measuring means may comprise a first motion detector which is adapted to generate a first pulsed motion detection signal in response to movement of the target, the frequency of said first pulsed signal corresponding to the speed of the target.

Typically each pulse corresponds to movement of the target in said orbit by a predetermined increment of distance, said measuring means being adapted to calculate the speed of the target from time between successive pulses.

In some embodiments, the motion detector comprises a first rotatable part and a first fixed part, the first rotatable part being coupled to the target such that movement of the target in its orbit when struck causes corresponding rotation of said first rotatable part about an axis of rotation relative to the first fixed part, wherein one of said first rotatable and fixed parts comprises a first optical encoder ring which is disposed substantially coaxially with the axis of rotation, and the other of said parts comprises a first photo-emitter and a first photo-detector adapted to detect light emitted by said first photo-emitter, wherein said first optical encoder ring comprises a plurality of regular formations which are circumferentially spaced at substantially equal intervals about said encoder ring to define a plurality of regular gaps therebetween, said first photo-emitter is arranged to direct a beam of light at the first encoder ring, such that the formations intermittently interrupt the beam as the first rotatable part rotates to produce a series of pulses of light; and said first photo-detector is arranged to detect said pulses of light and to generate a corresponding first pulsed motion detection signal in which each pulse corresponds to a pulse of light.

In some embodiments the practising aid may further comprise direction determining means for determining the direction of movement of the target in its orbit.

Preferably the direction determining means comprise a second motion detector which is adapted to generate a second pulsed motion detection signal in response to movement of the target, the frequency of said second pulsed signal corresponding to the

speed of the target and being substantially the same as the frequency of the first pulsed signal, and comparing means for comparing the first and signal signals, the phases of the first and second pulsed signals being off-set to allow said comparing means to determine, and said comparing means being configured to determine, the direction of movement of the target by quadrature.

The practising aid may further comprise a second motion detector comprising a second rotatable part and a second fixed part, the second rotatable part being coupled to the target such that movement of the target in its orbit when struck causes corresponding rotation of said second rotatable part about an axis of rotation relative to the second fixed part, wherein one of said second rotatable and fixed parts comprises a second optical encoder ring which is disposed substantially co-axially with the axis of rotation, and the other of said parts comprises a second photo-emitter and a second photo-detector adapted to detect light emitted by said second photo-emitter, wherein said second optical encoder ring comprises a plurality of regular formations which are circumferentially spaced at substantially equal intervals about said encoder ring to define a plurality of regular gaps therebetween, said second photo-emitter is arranged to direct a beam of light at the second encoder ring, such that the formations intermittently interrupt the beam as the second rotatable part rotates to produce a series of pulses of light; and said second photo-detector is arranged to detect said pulses of light and to generate a corresponding second pulsed motion detection signal in which each pulse corresponds to a pulse of light, the first and second motion detectors being configured and arranged such the frequencies of said first and second pulsed signals are substantially the same, and the phases of the first and second pulsed signals are off-set such that the direction of movement of the target can be determined by quadrature.

Typically the phases of said first and second pulsed signals are offset by about 90° .

The motion controlling means may comprise: a motor which is drivingly coupled to said target for controlling movement thereof; and motor controlling means for controlling operation of the motor.

Preferably, the motor controlling means comprise an H-bridge motor drive.

5 In some embodiments the practising aid may further comprise restoring means for restoring the target to a home position.

One of said first and second optical encoder rings may comprise a home formation having a unique size or spacing as compared with the other formations on said one ring for allowing the rotational orientation of the respective rotatable part, and thus the rotational
10 orientation of the target, to be determined.

The home formation may be configured so as to alter transiently the phase off-set between said first and second motion detection signals when the target is at its home position.

The respective rotatable part may be arranged such that said home finger is
15 disposed adjacent the respective photo-emitter and photo-detector when the target is in the home position.

The practising aid may further comprise home restoring means which are adapted to generate a home restoration signal for controlling said motion controlling means to move the target at a constant speed in its orbit, and to analyse the pulsed motion detection
20 signals generated by the respective motion detectors for determining when the home finger is disposed adjacent the respective photo-emitter and photo-detector, said home restoring means being configured to control the motion controlling means then to halt so that the target is positioned at the home position.

Typically a reset button is provided on the device which can be pushed by the user,
25 preferably with the heel of his putter, so that the target can be returned to the home position

before the user strikes the ball again and without the user having to make much adjustment to his positioning. This means that the user can remain substantially in the same position and repeat a particular putt several times until he is satisfied with his performance, aiding development of his muscle memory and increasing the likelihood that the user will be able to perform the putt well again, whether practising on the device or whether putting on a putting green.

The guiding means comprise a or substantially rigid arm, said target being mounted on one end of the arm and the other end of the arm being secured to one of said first and second rotatable parts.

Preferably the target comprises a standard golf ball, although it will be appreciated that any equivalent target having substantially the same dimensions and weight as a golf ball may be employed.

The device may further comprise display means for receiving and displaying information to a user. For example, the display means may be used to display to a user the numerical distance that the target has moved following a strike.

In some embodiments, the device may comprise communication means for transmitting data to and/or receiving data from external equipment. The external source may comprise a monitor, games console, personal computer, or an information store which contains operation parameters that can be accessed and processed by the device

The device may further comprise user input means for manually selecting of one or more parameters of operation of the practising aid. For example, the user input means may be used to select a desired stimp value. The user input means may comprise, for example, one or more buttons, switches, dials or the like.

In accordance with another aspect of the invention there is provided a golf stroke training device comprising: a supporting structure which is adapted to stand stably on the

ground in use; a rotator defining an axis of rotation, said rotator being rotatably mounted to said supporting structure such that said axis of rotation extends substantially vertically when the supporting structure stands on the ground, said rotator being adapted for rotation about said axis; a rigid or substantially rigid arm having an inner end and an outer end, said inner end being connected to said rotator, said arm being arranged such that said outer end is adapted to rotate in a substantially horizontal plane upon rotation of the rotator; a target adapted to be struck by a golf-club, said target being joined to said outer end of said arm, such that when the target is struck by a golf-club, the target is caused to rotate about said axis of rotation in a substantially horizontal orbit; a first optical encoder ring mounted on said rotator for rotation therewith, said first optical encoder ring comprising a plurality of regular formations which are circumferentially spaced about said axis of rotation at substantially equal intervals, said ring having a first inner side and a second outer side; a first photo-emitter adapted to emit a beam of light, and a first photo-detector adapted to detect light emitted by said first photo-emitter, said first photo-emitter and first photo-detector being fixedly mounted to said supporting structure on opposite sides of said first optical encoder ring, such that said beam is directed across the formations of the first optical encoder ring towards said first photo-detector, such that said formations interrupt the beam intermittently as the rotator rotates to produce a series of pulses of light, which pulses of light are detected by said photo-detector to produce a first pulsed motion detection signal, whereby the time between successive pulses of said pulsed motion detection signal is proportional to the speed of said target; a motor which is mounted to said supporting structure and drivably coupled to the rotator for adjusting the speed of the rotator; a motor controller for controlling the motor; and a microcontroller having an input which is adapted to receive said first motion detection signal, a clock configured to provide a constant measure of time, a microprocessor adapted continually to process said first

motion detection signal to determine the actual instantaneous speed of the target, said microprocessor being programmed to detect when the target is struck and to calculate the initial speed of said target, a memory device storing distance information relating a total notional distance to be travelled by the target to said initial speed, said microprocessor
5 being programmed for determining from said initial speed and said distance information a particular notional total distance to be travelled by said target and for determining from said particular total notional distance a relationship between the notional instantaneous speed of the target and the time elapsed since the target was struck, said microprocessor being further programmed to compare continually the actual instantaneous speed of the
10 target with said notional instantaneous speed to generate a velocity error value, and to generate a motor control signal corresponding to said velocity error value, and an output adapted for outputting said motor control signal to said motor controller for controlling the motor to adjust the actual instantaneous speed of the target to said notional instantaneous speed, such that the actual total distance travelled by said target in its orbit is substantially
15 the same as said particular notional total distance.

The memory device may store a plurality of different, predetermined, user-selectable values of notional resistance to rotation of the rotator, and stores distance information for each value of notional resistance relating the total notional distance to be travelled by the target to said initial speed, said microcontroller further comprises a user-
20 selection input component which is adapted to enable a user to select a desired one of said predetermined values.

The training device may further comprise a second optical encoder ring mounted to the rotator for rotation therewith, said second optical encoder ring being arranged substantially coaxially with said first optical encoder ring, and comprising a plurality of
25 regular formations which are circumferentially spaced about said axis of rotation at

substantially equal intervals, said ring having a first inner side and a second outer side; a second photo-emitter adapted to emit a beam of light, and a second photo-detector adapted to detect light emitted by said second photo-emitter, said second photo-emitter and second photo-detector being fixedly mounted to said supporting structure on opposite sides of said second optical encoder ring, such that said beam is directed across the formations of said second optical encoder ring, such that said formations can interrupt said beam intermittently as the rotator rotates to produce a series of pulses of light, which pulses of light are detected by said photo-detector to produce a second pulsed motion detection signal; said first and second optical encoder rings, said first and second photo-emitters and said first and second photo-detectors being configured and arranged such the frequencies of said first and second pulsed signals are substantially the same, and the phases of the first and second pulsed signals are off-set; wherein said input is further adapted to receive said second motion detection signal, and said microprocessor is further programmed to compare said second motion detection signal with said first motion detection signal to determine the direction of rotation of the rotator by quadrature.

The motor controller may comprise an H-bridge motor drive.

In some embodiments, one of said first and second optical encoder rings comprises a home formation of unique size or unique spacing as compared with the other formations on said one optical encoder ring, said home formation being positioned on said one encoder ring such that said home formation is positioned adjacent the respective photo-emitter and photo-detector when the target is in a home position; and said microprocessor is programmed with a selectively operable home restoration routine, which home restoration routine comprises outputting appropriate motor control signals for controlling said motor to drive said rotator at a constant angular velocity whilst processing the respective motion detection signal to detect the home formation, and when said home

formation is detected ceasing output of said motor control signals to halt operation of the motor, thereby bringing said rotator to rest at the home position.

In accordance with a further aspect of the invention there is provided a putting practising aid comprising: a stationary support; a rotator mounted to the stationary support and adapted for rotation about a substantially vertical axis; a target mounted to said rotator for rotation about said axis in a substantially horizontal orbit, said target being adapted to be struck by a golf putter; and motion controlling means for controlling rotation of said rotator by applying a predetermined resistance to movement of the target to simulate the feel of putting a golf ball on a real green.

The motion controlling means may be configured to apply selectively a plurality of different, predetermined, user-selectable values of resistance to rotation of the rotator, and means are provided to enable a user to select a desired one of said predetermined values.

Preferably said motion controlling means comprise a motor drivably connected to said rotator.

The motion controlling means may comprise means for measuring the initial velocity of the rotator, clock means for measuring the time elapsed from striking the target, means for calculating a notional total distance to be travelled from said initial velocity and said value of resistance to rotation, means for calculating a notional relationship between notional instantaneous speed of said rotator and elapsed time after striking from said notional total distance to be travelled, means for continually measuring the actual instantaneous speed of the rotator at predetermined elapsed times after the target is struck, speed comparing means for comparing the actual instantaneous speed of the rotator at each elapsed time with the notional instantaneous speed, and means for adjusting the speed of the rotator as necessary to the notional instantaneous speed.

The device is typically mounted on a base plate, the plane of which is intended to be oriented horizontally during use of the device, and arranged such that the plane of movement of the target lies substantially parallel to and in close proximity to the uppermost surface of the plate, but which does not touch the plate. Preferably distance indicators are marked on the base plate, so that a user can clearly see how far the target has moved. One or more spirit levels positioned on the top of the device and adjustable feet on the lowermost side of the base plate may be provided for ensuring the device is horizontal before a shot is played.

The device may also include a metronome for allowing a user to practice the timing of their stroke. Preferably the metronome can be switched on or off independently of the main device, so that it can be used as and when it is required.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

FIG. 1 is a perspective view from above and to one side of a golf stroke training device in accordance with the present invention;

FIG. 2 is a plan view of the golf stroke training device of FIG 1;

FIG. 3 is a cross-sectional view of the golf stroke training device of the present invention along the line A-A of FIG. 2;

FIG. 4 is a cross-sectional view of the golf stroke training device of the present invention along the line B-B of FIG. 2;

FIG. 5 is a perspective, exploded view of the golf stroke training device of FIGS. 1 to 4;

FIG. 6 is an enlarged, perspective exploded view of a rotator unit which forms part of the golf stroke training device of FIGS. 1 to 5;

FIG. 7 is a perspective view of part of the rotator unit as shown in FIG. 6;

FIG. 8 is an enlarged, perspective view of a printed circuit board and associated electronic components of the golf stroke training device as shown in FIGS. 1 to 5;

FIG. 9 is a block diagram of the electronic components of the golf stroke training device in accordance with the present invention; and

5 FIG. 10 is a schematic representation of an H-bridge drive circuit;

FIGS. 1 to 5 show a golf stroke training device in accordance with the present invention, indicated generally by reference numeral 1. The device includes a generally flat base plate 2 having an upper surface 34 and an underside 35. As seen in FIG. 2, the base plate has a substantially linear front edge 14, an opposite arcuate rear edge 36 and two
10 opposite side edges 37, 38. Preferably the base plate is formed from a durable thermoplastic synthetic resin material which may be injection moulded.

As best seen in FIGS. 3 and 4, supported at a central region of the base plate 2 is an upright spindle 3. The spindle, which is formed from metal, has, at a lower end thereof, a radially protruding collar portion 4 and a shoulder 23 at its uppermost end. The lowermost
15 end of the spindle 3 is inserted into a hole provided in the base plate 2, such that the lowermost end of the collar portion rests on the upper surface of the base plate 34. The lowermost end of the spindle 3 extends through the hole in the base plate, such that a small length of spindle protrudes from the underside of the base plate 2. The spindle 3 has a threaded bore which extends substantially along the entire length of the spindle 3. The
20 spindle is removably secured to the base plate 2 by means of bolt which is inserted into the lowermost end of the bore; the bolt having an enlarged head portion which engages the underside of the base plate 35.

A rotator unit 5 is rotatably mounted on the spindle 3 and is supported by two stacked, annular roller bearings units 6, which may be conventional ball bearings of the
25 kind that are widely commercially available. The roller bearing units 6 are mounted on the

spindle 3 with the lowermost of the bearings units being supported on the upper surface of the collar portion 4. The roller bearing units 6 define a substantially cylindrical outer surface.

As shown in FIG. 7, the rotator unit 5, has a solid annular bottom wall 7 which faces the base plate 2. Extending upwardly and orthogonally from the solid bottom wall is a generally cylindrical hub portion 8. The hub portion is shaped to fit tightly over the spindle 3 and the bearings 6, such that an inner surface of the hub portion 8 abuts substantially contiguously with the outer surface of the bearings units 6. On the outer surface of the hub portion 8, a shoulder 21 is formed adjacent to the upper end of the hub portion 8.

Substantially co-axial with the inner hub portion 8, are two radially spaced, outer and inner optical encoder rings 9, 10 respectively which also are formed integrally with the rotator unit 5. Each optical encoder ring 9, 10 extends upwards and orthogonally to the plane of the bottom wall 7 of the rotator unit 5. The outer ring 9 defines the radial extremity of the rotator unit 5, and the inner ring 10 is positioned between the outer encoder ring 9 and the hub portion 8. Preferably the rotator unit 5 is formed as an integral unit by injection moulding a thermoplastic synthetic resin material, although a unit cast from metal could equally be incorporated into the device.

An annular gear member 22 is mounted on the shoulder 21 of the hub portion 8 as shown in FIGS. 3, 4 and 5. The annular gear member 22 is press-fitted onto the hub portion 8 so that it forms a tight fit. The outermost edge of the annular gear member 22 extends into a space between the hub portion 8 and the inner optical encoder ring 10, and has a series of teeth formed thereon for engaging a pinion gear 32 (described below). Preferably the annular gear member 22 is moulded from thermoplastic synthetic resin material, and thus may alternatively be formed integrally with the rotator unit 5.

As shown in FIG 5, a modified standard golf ball 11 is attached to the rotator unit 5 via a substantially rigid cantilever arm 12 having inner and outer ends. The golf ball 11 has a blind bore of substantially constant internal diameter that extends from the surface of the bore along a radial axis to a depth at least approximately equal to the radius of the ball 11.

5 The internal diameter of the bore and the cross-section of the arm 12 are of dimensions that allow an interference fit between the bore and the outer end of the arm. An adhesive may first be applied to the outer end of the arm or the surface defining the bore so that the assembly is held together more securely.

The diameter of the arm 12 is significantly smaller than that of the ball 11, so that

10 the arm 12 does not interfere with a strike to the ball made by a user of the device. Furthermore, it is preferred that the arm 12 be made of a fibre composite material. For example, a carbon fibre arm has good durability, whilst at the same time being light in weight. If the arm was too heavy, this would be felt by a user of the device and would impart an unnatural feel to any stroke made. To minimise the weight of the arm 12, the arm

15 may be hollow, as shown in FIG. 3.

The inner end of the arm 12, which is secured to the rotator unit 5, is inserted through the outer and inner optical encoder rings 9, 10 of the unit via two aligned holes 24, 27 provided respectively in the encoder rings, as shown in FIG. 3. The hole 24 of the outer encoder ring is visible in FIG. 7. The arm 12 forms a tight fit in the holes 24, 27.

20 Because the rotator unit 5 is rotatably mounted on the spindle, the attachment of the ball 11 and arm 12 thereto means that the ball can move in a circular orbit about the spindle 3, the length of which orbit is defined by the distance between the ball 11 and the spindle 3. Generally, it is preferred that the ball 11 be mounted at a distance from the spindle 3 such that in one complete orbit, the ball travels a total distance of at least 1.22m

25 (4 feet). Preferably, the holes 24, 27 in the outer and inner rings 9, 10 are aligned so that,

when the arm 12 is inserted, the lowermost point of the ball 11 is disposed as closely as possible to the upper surface of the base plate 2, without the ball touching the base plate 2, or being impeded at any point in its orbit. Thus, the ball 11 may be positioned so that its lowermost point is disposed only about 1 to 5 mm above the base plate, although in some embodiments the distance may be greater than this. An advantage of positioning the ball 11 as close as possible to the base plate 2 is that the closer the target is to the ground, the more accurately the device simulates the feel of putting a real golf ball on a putting green, thereby allowing a user to develop a feel for a natural putting stroke.

As shown in FIGS. 1, 2 and 5, the base plate 2 has a series of optional putter alignment markings on its upper surface 34, juxtaposed the front edge of the base plate 2. The alignment markings comprise a series of straight lines which are spaced along the length of the front edge 14, and extend substantially perpendicularly to said edge. Said markings may be either superimposed the upper surface of the base plate or moulded thereon. The alignment markings 13 are of sufficient length so they are visible to a user of the device for aligning the head of his putter therewith.

At a start position, as shown in FIG. 2, the ball 11 is suspended over the markings at a central point, such that the markings are divided into two equal groups 18A, 18B, one group to either side of the ball 11. In order to practise his putting stroke, a right handed user will position the head of his putter to the right of the ball 11 and use the alignment markings to the right of the ball 18A for aligning his shot. Conversely, a left handed user will use the alignment markings to the left of the ball 18B for aligning his stroke. Typically, the alignment markings on either side of the ball 11 are spaced approximately 25.4mm (1 inch) apart. A user can refer to these markings not only to align the head of his putter so that it is square to the ball 11, but also for the purpose of lining up his back-swing and controlling his follow-through for imparting more or less power to the shot.

In addition to the putter alignment markings 13, the base plate 2 has a series of optional distance markers 15 which are visible on its upper surface. In the embodiment shown, the distance markers are formed by means of a plurality of formations 16, moulded into the base plate 2 in a particular pattern. Each formation 16 forms an arcuate, half cylindrical recess in the upper surface of the base plate 2, and together the formations are arranged in a circle to define a regularly interrupted half-toroid. Adjacent formations 16 are separated from each other by a narrow strip 15 of flat-moulded plastic, the narrow strips forming the distance markers. Each distance marker 15 is arranged in a radial fashion with respect to the spindle 3. As shown in FIGS. 3 and 4, the formations 16, protrude from the underside of the base plate 2, so that when the base plate 2 is placed on the ground, the formations 16 act as feet for supporting the base plate 2 slightly above the ground.

The circle of formations 16 and the orbit of the ball 11 are substantially mutually concentric, and preferably, the circle of formations 16 has a smaller radius than the orbit of the ball. This means that the arm 12 moves directly over the formations 16 and distance markers 15. By ensuring that the formations 16 and distance markers are of substantially equal dimensions, and ensuring that, at its start position, the arm 12 rests over one of the distance markers 15, the orbit is effectively divided into a number of smaller units. In the device shown in FIGS. 1, 2 and 5 the orbit is divided into twelve substantially equal sections. As the path is 1.22m (4 feet) in length, each time the arm 12 passes over one of the distance markers 15, an advancement of the ball of 107mm (4 inches) has been made. In other embodiments, number markings and/or further radial lines may be provided on the upper surface of the base plate 34 to assist a user in determining how far the ball 11 has moved. Alternatively, the distance markers may consist of a series of radial lines marked on the upper surface of the base plate 2.

As shown in FIG.1, an optional mirror 17 is attached to the upper surface of the base plate 2. The mirror is positioned adjacent the front edge 14 of the base plate 2, in-between the two groups 18A and 18B of putter alignment markings 13 and underneath the start position of the ball 11. The mirror is preferably sufficiently large that a user can use the mirror to ensure that his head is directly over the ball before he plays a stroke.

As shown in FIGS. 3 to 7 each of the outer and inner optical encoder rings 9, 10 comprises a series of upwardly extending fingers 19, 20. The fingers 19 of the outer encoder ring 9 are of substantially equal dimensions and spacing. The fingers 20 of the inner encoder ring 10 are also of substantially equal dimensions and spacing. The function of the fingers 19, 20 is to interrupt intermittently a beam of light - a separate beam of light being directed at each encoder ring (as described below) - as the rotator unit 5 rotates to produce a series of pulses of light which can be detected to generate a pulsed signal. So that each ring 9, 10 produces a pulsed signal of substantially the same frequency for a given speed of rotation of the rotator unit 5, the width and spacing of the fingers 20 of the inner encoder ring 10 are proportionally smaller than the width and spacing of the fingers 19 of the outer encoder ring 9, as shown most clearly in FIG. 7. Thus, as both rings 9, 10 rotate, the inner encoder ring 10 moves at a relatively slower circumferential speed than the outer encoder ring 9, and therefore the fingers 20 of the inner encoder ring 10 must be of a smaller width and spacing than the fingers 19 of outer encoder ring 9 in order to achieve substantially the same frequency of light pulses.

Unique to the inner encoder ring 10 is a home finger 25 which is of double the width of the other fingers 20 of the inner encoder ring 10. Furthermore, to one side of the home finger 25 is a home space 26 which is double the width of the spaces between all the other fingers 20 of the inner encoder ring. The reason for the difference in finger arrangement between the inner and outer encoder rings relates to the respective functions

of those rings. The fingers of the outer optical encoder ring 19 form part of an arrangement for detecting the speed of the ball 11 and for determining the direction of movement of the ball 11, whilst the fingers of the inner encoder ring 10 form part of an arrangement for determining the direction of movement of the ball 11 and for returning the target 21 to the start position, as described in further detail below.

As shown in FIGS. 3 and 4, a printed circuit board (PCB) 40 is supported on the shoulder 23 of the spindle 3 above said pinion gear 22. The PCB 40 carries electronic components of the device as described in more detail below. The PCB, which is generally rectangular in shape, has a hole 41 formed in its central region for mounting on the uppermost end of the spindle 3. The hole 41 is dimensioned to allow the PCB to rest on the shoulder of the spindle 23. To secure the PCB in place, a second bolt (not shown) engages the uppermost end of the bore of the spindle 3 and has an enlarged head which engages the upper surface of the PCB. Preferably the PCB has a thickness of about 3.2mm, which gives the board added strength and longevity. As can be seen in FIGS. 3 and 4, the PCB 40 is supported on the spindle 3 a small distance above the uppermost extremities of the hub portion 8 and the optical encoder rings 9, 10; thus the PCB 40 does not interfere with the free rotation of the rotator unit 5.

With reference to FIG. 6 mounted to the underside of the PCB 40 are two generally -shaped optical sensor assemblies 50, 51. Each optical sensor assembly has a generally first rectangular upper portion 52, 53 having a flat upper surface, and two parallel arms 56, 56' and 57, 57' which depend from said rectangular portion 52, 53. The rectangular upper portions 52, 53 serve as points of attachment for attaching the sensor assemblies to the underside of the PCB 40. Preferably, each rectangular portion 52, 53 has two opposing ends, and, at each end, a hole 54, 54', 55, 55' through which a rivet or the like may be inserted into the PCB 40 for securing the optical sensor assembly to the underside of the

PCB. The arms 56, 56' and 57, 57' carry a photo-detector and an opposing photo-emitter, which are aligned on inwardly facing surfaces of the arms. Accordingly, for each optical sensor assembly, when a beam of light is emitted by the photo-emitter, the light is directed at and is detected by the corresponding photo-detector. Each photo-detector is adapted to output a high voltage when it detects light emitted by the corresponding photo-emitter and a low voltage when it does not detect light emitted by the corresponding photo-emitter.

As shown in FIG. 8, the PCB 40 has two arcuate holes 42, 43 respectively, each of which follows an arc having its centre on said spindle 3. Each of the arcuate holes is flanked by a series of smaller round holes 42', 43'. The smaller holes 42' and 43' are each paired with another radially spaced smaller hole 42', 43' positioned directly opposite on the other side of the respective arcuate hole 42, 43, such that each arcuate hole has a series of pairs of smaller holes which are circumferentially displaced from each other. The paired smaller holes 42' 43' facilitate the attachment of the optical sensor assemblies 50, 51 to the PCB 40 via rivets or the like inserted through the holes of the rectangular upper portions 52, 53 of the sensor assemblies 50, 51 and into the PCB 40. The series of pairs of holes 42', 43' allows for adjustment of the positioning of the optical sensor assemblies 50, 51. The arcuate holes 42, 43 allow access to the optical sensor assemblies 50, 51 for connecting them to the circuitry of the device and to a power supply.

An outer one of the optical sensor assemblies 50 is positioned on the underside of the PCB 40 such that its two arms 56, 56' lie on opposite sides of the outer optical encoder ring 9. The photo-detector and photo-emitter of the outer optical sensor assembly 50 lie in a plane that is level with the fingers 19 of the outer ring 9. The other optical sensor assembly 51 is disposed radially inwardly with respect to the outer sensor assembly 50, owing to the relative positions of the paired holes 42', 43' as described above, and is positioned such that its arms 57, 57' lie on opposite sides of the inner encoder ring 10. The

photo-detector and photo-emitter of the inner sensor assembly 51 are positioned such that they lie in a plane that is level with the fingers 20 of the inner encoder ring 10.

As the rotator unit 5 rotates, the optical beams produced by photo-emitters of the optical sensor assemblies 50, 51, which beams are directed towards their corresponding photo-detectors, are intermittently interrupted by the fingers 19, 20 of the outer and inner optical encoder rings 9, 10 respectively, such that the photo-detectors of the outer and inner optical sensor assemblies 50, 51 respectively produces pulsed output outer and inner motion detection signals, each comprising a series of motion detection cycles, each motion detection cycle comprising a first transition from a low output voltage to a high output voltage when the photo-detector detects the leading end of a space after a finger, a subsequent transition from high output voltage to low output voltage when the photo-detector detects the leading edge of the next finger following the space, and then a further low to high output voltage transition when the next space is encountered. The pulsed motion detection signals are used by the device for performing a number of functions, including determining the distance travelled by the ball, calculating the instantaneous speed of the ball, determining the direction in which the ball has been hit and determining whether the ball is at the start position; these functions are described in further detail below. The inner and outer optical sensor assemblies 50, 51 are arranged such that for a single motion detection cycle the inner motion detection signal of the inner sensor assembly 51, when the rotator unit 5 is rotated in one direction, is offset from the outer motion detection signal of the outer sensor assembly by about 90° . Conversely, when the rotator unit 5 is rotated in the opposite direction, the inner motion detection signal of the inner sensor assembly 51 is offset from that of the outer sensor assembly 50 by about 270° . Such an out-of-phase arrangement of the inner and outer encoder rings 10, 9 and inner and outer sensor assemblies 51, 50 is referred to in the art as quadrature. Quadrature is well

known in the art and may be used in the present invention for determining the direction of rotation of the ball 11, as described below.

As shown in FIG. 3, an electric motor 30 is mounted to the upper surface of the PCB 40 and is secured to the PCB by three bolts which engage in three respective threaded bores 33 provided in the motor casing. (Only two of the bolts are shown in FIG. 3). The bolts are inserted from the underside of the PCB 40 through three holes 44 (see FIG. 8) provided in the PCB 40, the spacing of which corresponds to the three bores 33 provided in the motor 30 and have enlarged head portions to engage the underside of the PCB 40. The motor 30 is mounted over a further hole 45 in the PCB 40 through which a depending drive shaft 31, coupled to the motor 30, extends downwards into a cavity of the optical encoder unit 5 between the hub portion 8 and the inner ring 10. A pinion gear 32 as mentioned above is mounted on the free end of the drive shaft 31, and is positioned such that its teeth engage with the teeth of said annular gear member 22. Thus, rotation of the drive shaft 31 and pinion gear 32 causes the rotator unit 5 to be rotated, thereby allowing rotation of the rotator unit 5 - and thus motion of the ball 11 - to be controlled by the motor 30.

Operation of the motor 30 is controlled by electronic motor control means which are provided on said PCB 40. With reference to FIG. 9, said motor control means comprise an H-bridge motor drive circuit 82 which allows the speed and direction of the motor 30 to be controlled. As shown in FIG. 10, the H-bridge motor drive circuit 82 comprises four switches Q1-Q4, and two feedback voltages Va and Vb. The motor 30 can be driven in one direction, in this case clockwise, by turning on Q1 and Q3 such that M+ is connected to Vpos and M- is connected to Vneg. The longer that Q1 and Q3 are on, the greater the speed of the motor 30. Thus, by pulsing Q3 on and off, the speed of the motor can be controlled. Conversely, the motor can be driven in the opposite direction by turning on Q2 and Q4, where M+ is connected to Vneg and M- is connected to Vpos. The speed of the

motor is controlled by pulsing Q4 on and off. Accordingly, the drive shaft 31 of the motor 30 can be driven in either a clockwise or anti-clockwise direction for speeding up or slowing down the ball 11, depending on the direction in which the ball has been hit. The pulsing of the switches on and off is a process generally referred to as Pulse Wave Modulation (PWM) and will be recognised by those in the art as a energy efficient way of controlling motor speed.

Further supported on the PCB 40 is a liquid crystal display unit ('LCD') 60 for displaying information to a user. The LCD unit is substantially rectangular in shape and, as best seen in FIG. 8, has a flange 61 at its lowermost edge which flange extends about the entire unit 60 for securing the LCD unit 60 to the PCB 40. Said flange 61 has four holes 62 formed therein, one provided at each corner of the LCD unit, for attaching the LCD 60 to four upstanding hollow posts 63. Attachment is achieved by inserting a bolt (not shown) downwardly through each of the holes 62 and engaging it with a corresponding thread formed in a central cavity of a respective one of the posts 63. The posts 63, when secured to the LCD unit 60, depend from the lower surface of the LCD unit and the lowermost ends of the posts abut the PCB 40. The posts 63 are attached to the PCB by four more bolts which extend upwardly through four correspondingly positioned holes 46 provided in the PCB 40. Thus, the LCD unit 60 is supported over and is spaced from the PCB 40, such that other components can be mounted to the PCB 40 in a rectilinear recess defined between the LCD unit and the PCB.

With reference to FIGS. 3-5, the PCB 40 also supports a generally dome-shaped casing 64 which is shaped to cover and protect the rotator unit 5 and electronic components of the device 1. The casing comprises a cylindrical skirt 65 which extends downwards over the PCB 40, protecting the PCB and electronic components within the interior of the casing 64, but the skirt 65 does not extend so far that it interferes with the movement of the ball

11 about its circular path. Four depending pillars 73 are moulded on the inner surface of the casing 64. All four pillars are shown in transverse section in FIG. 2. Each of the four pillars 73 has a bore formed therein, which aligns with a respective one of four corresponding holes 47 provided at each corner of the PCB 40. Accordingly, four bolts can
5 be inserted from the underside of the PCB 40, through the holes 47, into the bores of the pillars 74 for securing the casing 64 to the PCB 40.

The casing 64 has a plurality of shaped apertures provided in its crown for allowing various components of the device to be accessed or clearly seen from above, as shown in FIG. 5. One aperture 66 is provided for allowing the LCD unit 60 to be read by a user. Two
10 further apertures 67 are provided for accessing push buttons 68 which enable a user to make selections related to operation of the device 1. The apertures 67 and consequently the push buttons 68 are positioned one to either side of the LCD unit 60. This enables at least two player options to be displayed simultaneously at either end of the LCD unit 60. A user can then use the button 68 closest to his preferred option in order to make a selection. Each
15 push-button 68 is preferably formed from rubber and has a stalk 69 *via* which each button is able to contact a respective one of two pressure sensitive pads 75, 76 (see FIG. 9) which are provided on the upper surface of the PCB 40. Each time a particular button 68 is pushed, pressure is exerted on the corresponding underlying pressure sensitive pad 75, 76 and the pad generates a corresponding command signal.

20 With reference to FIG. 3, a box-shaped recess 70 is also formed in the casing 64. The recess 70 forms a housing for a battery pack 71. In order to accommodate the housing 70 within the device 1, a rectangular section of the PCB 40 is cut away at one of its edges, as shown in FIGS. 5 and 8. A removable access panel 72 is provided for closing the battery housing, which panel 72 can be easily removed for inserting and removing cells.

The PCB 40 carries the electronic components necessary to process the signals received from the optical sensors 50, 51 and push buttons 68. Said electronic components comprise a microcontroller 80 including a microprocessor 84, and a suitable memory device 81 comprising pre-stored application software for operating the microcontroller in the manner described below. The microcontroller is "clocked" by a 12 MHz quartz crystal, which is internally divided into twelve to provide an internal 1MHz time-base, thereby providing basis for measuring time to within 1 μ s. The microcontroller 84 comprises an on-board timer-counter, typically a Programmable Counter Array (PCA), which includes a first 16 bit counter for counting from 0 to 65535. The first counter is free running and is adapted to run continuously without stopping during normal operation of the device. The application software provides a first software counter. As soon as the first counter reaches 65535 and returns back to 0, an interrupt is generated which increments by 1 the first software counter. The PCA further comprises two further "outer" and "inner" 16 bit registers, which registers are associated with the outer and inner optical sensor assemblies 50, 51 respectively to act as a "capture" register, the function of which is described below. Further associated with the microcontroller is a timer-counter which runs at about 2000Hz. This timer-counter is used in measuring the speed of the ball as described below.

The functioning and interaction of the electronic components of the device are now described in detail, in order further to describe the device in accordance with the present invention and its operation.

With reference to FIG. 9, the microcontroller 80 is central to the operation of the device. The microcontroller forms the central processing unit of the device and is adapted to receive and process in accordance with said application software input signals from the various peripheral components of the device, including said command signals derived from selections made *via* the push buttons 68, and said motion detection signals derived from

the optical sensor assemblies 50, 51 as described above. The outer motion detection signal from the outer optical sensor assembly 50 is adapted to generate a high level interrupt on each transition from low voltage to high voltage. The microcontroller is further configured 80 to co-ordinate responses to the input signals it receives and outputs control signals, including a motor drive signal for controlling said motor control means to control 5 movement of the ball 11, and a display signal adapted to control said LCD unit 60 for displaying information to a user. of how far the ball 11 has travelled. Generally this information is updated about twice a second so that a user can follow the progress of the ball whilst it is moving by referring both to the LCD unit and the ball 11 and its position in 10 its circular path.

In use the ball is arranged at said start position, ready to be struck by a user using a putter. With the ball 11 in the start position, the microcontroller 80 operates in accordance with the application software in a 'ready for putt' state. When the ball 11 is struck, the ball 11 is caused to rotate in its orbit as described above, with the direction of the strike - and 15 consequently the direction of rotation of the rotator unit 5 - depending on whether the user is right or left handed. When the first low to high output voltage transition is detected by the outer sensor assembly 50, i.e. when the outer sensor assembly first detects a space - usually on the second finger transition - , an interrupt is generated which triggers the microcontroller to operate in a 'measuring velocity' state to measure the initial speed (V_{init}) 20 of the ball 11. In this state, the instantaneous value (t_1) of the first 16 bit counter at the moment when the first low to high voltage transition of the outer motion detection signal occurs is captured on the outer 16 bit register,. The outer 16 bit register then captures the value (t_2) of the first counter when the next low to high voltage transition of the outer motion detection signal occurs, i.e. once one space and finger have passed between the 25 arms of the outer optical sensor assembly 50. The difference between the first and second

counter values is calculated by the microcontroller. This provides a difference value (Δt) corresponding to the time elapsed between the two consecutive low to high output voltage transitions:

$$\Delta t = t_2 - t_1$$

5 From the width (W) of each finger and space, this said difference value is used by the application software to calculate the initial speed of the ball 11.

$$V_{init} = k_1 \cdot W / \Delta t$$

where k_1 is a constant.

During rotation of the ball, the microcontroller maintains a software position

10 variable which is reset when the ball is at the start position. Each time the microcontroller is interrupted by a low to high transition of the outer motion detection signal, the microcontroller determines the direction of rotation of the ball 11, as described below, and increments the position variable by +1 or -1 depending on the direction of rotation to determine the instantaneous distance travelled by the ball.

15 Furthermore, the instantaneous value (t_n) of the first counter at each successive transition from low output voltage to high output voltage of the outer motion detection signal is recorded by the outer register, and the difference between the instantaneous value and the previous value (t_{n-1}) is calculated to measure the instantaneous speed (V_t) of the ball 11:

20
$$V_t = k_1 \cdot W / (t_n - t_{n-1})$$

A second 16 bit counter is provided in order to improve resolution when the ball is moving slowly. As a way of doubling resolution, the microcontroller 80 could also be configured to record each high to low output voltage transition of the outer motion detection signal in addition to each low to high output voltage transition.

In order to determine the direction of rotation of the ball 11, the microcontroller 80 is configured to compare the phase relationship as between the outer and inner motion detection signals by quadrature. If, as described above, the signals are about 90° out-of-phase then the microcontroller 80 determines that the ball 11 is moving in one direction, and if the signals are about 270° out-of-phase, then the microcontroller determines that the ball 11 is moving in the opposite direction.

Once the initial speed (V_{init}) has been measured, a notional total distance (D_{total}) to be travelled by the ball 11 is calculated by the microcontroller in accordance with the application software, taking into account any stimp value (S_n) which may have been selected by the user, using the equation:

$$D_{total} = V_{init}^2 / (k_2 \cdot S_n)$$

where $k_2 \cdot S_n$ is a deceleration factor dependent on the stimp value.

Alternatively, the application software may comprise a look-up table in the memory device 81 relating the notional total distance (D_{total}) to be travelled to the measured initial speed (V_{init}) of the ball for each of one or more user-selectable stimp values (S_n).

The microcontroller is configured then to calculate from the notional total distance to be travelled by the ball 11 (D_{total}) how quickly the ball 11 should decelerate from its measured initial speed so that it travels an actual total distance substantially equal to said notional total distance. This is achieved by generating a notional relationship between the instantaneous velocity (V_n) of the ball 11 and the elapsed time (t) after it has been struck, thus creating a velocity control algorithm:

$$V_n = f(t)$$

Alternatively, a look-up table of predetermined velocity control algorithms could be stored in the memory device 81 to provide a corresponding control algorithm for each derived notional total distance .

Once the notional total distance and velocity control algorithm have been obtained, the microcontroller 80 operates in a 'decelerating state', during which control of the velocity of the ball 11 is achieved by sampling the instantaneous velocity (V_t) of the ball 11 every 40 ms as measured by said timer-counter, which has a cycle time of 500 μ s.

When the timer-counter reaches 500, a second internal software counter is incremented by 1, which second software counter, when it reaches 80, signals the elapse of 40 ms, causing a low priority software interrupt to be generated, which in turn triggers the microcontroller to compare the measured instantaneous speed (V_t) of the ball 11 with the notional speed (V_n) at that time according to the velocity control algorithm, and to derive an instantaneous

velocity error value (ΔV):

$$\Delta V = V_t - V_n$$

Based on the instantaneous velocity error value (ΔV), the microcontroller calculates an appropriate motor control signal to control the motor control means if necessary to adjust the speed of the rotator unit 5 to cause the ball 11 to decelerate at a rate such that it will stop at about the notional total distance (D_{total}). The motor control signal is calculated from the instantaneous velocity error value in accordance with a proportional control algorithm that has desired speed as an input and motor drive as an output. If the actual speed (V_t) is higher than the desired speed (V_n), then using a table of desired speeds of the ball against percentage motor performance required to achieve those speeds - as derived by experiment and taking into account a margin of error-, the motor drive can be used to reduce the speed of the ball to the desired speed. Conversely, if the actual speed of the ball is lower than the desired speed, then the motor drive can be used to increase the actual speed of the ball. Such sampling and control of the ball's velocity occurs every 40 ms until the ball 11 stops. Typically the device may be configured such that when no further low to high voltage transitions of the outer motion detection signal are seen within a period of

about two seconds, the microcontroller is programmed to determine that the ball has stopped moving and thus ceases any further control of the motor 30. Whilst the ball 11 is moving, the positional information obtained may be used to calculate continually how far the ball has travelled. This real-time distance information is used to update the distance as displayed on the LCD unit 60.

In order to compensate for any difficulties that the motor may have in driving the ball 11 at low speeds, the velocity control algorithm may be calculated so that the desired final distance is reached before the ball reaches a velocity of zero. For example, the velocity control algorithm may be calculated so that the desired final distance is reached when the ball 11 is travelling at a speed of about 250 mm/s (10"/s). Generally the calculated notional distance can be expressed as a number of fingers 19. For example, after a strike by a user the microcontroller may calculate from the initial velocity of the ball 11 a notional total distance of travel of the ball 11 of 1.22 m (4 feet) which corresponds to a total of sixty fingers passing between the arms of the outer optical sensor 50. The microcontroller 80 compensates for the fact that generally three fingers 19 will have passed between the arms of the outer optical sensor assembly 50 before the microcontroller is able to calculate the notional distance of travel of the ball 11. Thus, once the notional distance is determined - and from this, the number of fingers that the outer optical sensor assembly 50 must detect in order to reach that notional distance -, a total of three fingers is subtracted from the total number of fingers, such that in the case of sixty fingers, the microcontroller decelerates the ball 11 so that it stops after a detection of fifty seven fingers. In actual fact the microcontroller subtracts a further one finger from this total and controls the velocity of the ball so that it decelerates to its lowest controllable speed, i.e. 250 mm/s (10"/sec) at the fifty-sixth finger. As soon as fifty six fingers have been detected by the microcontroller 80, the microcontroller causes the ball 11 to stop at the next finger, so the ball 11 travels the

notional distance and effectively slows from a speed of 250 mm/s (10"/s) to 0 mm/s on the last finger. This avoids any difficulties that may be associated with controlling the motor 30 to drive the ball 11 at speeds slower than 250 mm/s (10"/s).

After the ball 11 has been struck, it is likely that the ball will stop somewhere other than the start position. Thus, before another strike is made, the ball 11 needs to be repositioned at the start. Although it is possible for the user to return the ball to the start position manually, the device described herein is adapted to return the ball 11 automatically to the start position.

Firstly, an input selection by a user is required and this is achieved by pushing one of the push buttons 68 so that a user input command signal, in this case a home command signal, is transmitted to the microcontroller 80. When such a signal is received by the microprocessor 80, the microprocessor immediately outputs a home restoration control signal which is transmitted to the H-bridge motor drive 82 for initiating a relatively slow, constant-velocity rotation of the rotator unit 5. The microprocessor 80 then begins analysing the outer and inner motion detection signals. As the rotator unit 5 rotates, the microcontroller detects a normal 90° out-of-phase relationship between the outer and inner motion detection signals. However, when the inner sensor assembly 51 detects said home finger 25, the phase relationship between the outer and inner signal changes from 90° out-of-phase to 270° out-of-phase owing to the double the width of the home finger as compared with all other fingers 20 on the inner encoder ring 10. The microcontroller 80 recognises that this change of phase signals that the ball 11 has been returned home. The device is configured to stop when the next normal finger 20 on the inner encoder ring 10 is detected by the inner optical sensor assembly 51. This means that the home space also passes the inner optical assembly 51, thereby returning the phase relationship back to 90° out-of-phase.

The device is configured so that when the ball 11 is at the start position, the home finger 25 and home space 26 of the inner optical encoder ring 10 lie directly adjacent the arms of the second sensor assembly 51 being one standard-sized finger removed therefrom.

In use, the device 1 as shown in the accompanying drawings is placed by the user on the ground and is activated by operating an appropriate power-switch (not shown). The user then orientates himself adjacent the device, so that he is facing the device with the front edge 14 of the base plate 2 facing him. The LCD unit 60 indicates that the device is switched on and a number of play options are indicated to the user before he plays his stroke, in accordance with the programme. Such options include selecting a stimp value of the green and also resetting the device so that the ball 11 is returned home before the shot is played. Such selections can be made using the buttons 68 positioned on top of the device (as described above). Once the appropriate selections have been made, the user stands facing the device, adopts an appropriate stance, aligns his putter with the ball 11 at the start position and strikes the ball. The ball 11, once struck, orbits the spindle 3 in either a clockwise or anti-clockwise direction, depending on whether the user employs a left handed or a right handed stroke. The device determines in which direction the ball 11 has been struck and calculates the initial velocity (V_{init}) of the ball based on the information it receives from the optical sensor assemblies 50, 51, as described above. The harder the ball 11 is struck, the faster its initial speed of rotation and thus the further the ball 11 should travel. The device uses initial speed measurement, together with a selected stimp value (S_n), to calculate a theoretical final resting distance of the ball. The theoretical final resting distance is then used to generate a profile of desired ball velocity against time. The microcontroller 80 regularly samples the velocity (V_t) of the ball and compares it with the desired ball velocity. If the actual velocity of the ball is higher or lower than the desired ball velocity, a proportional control velocity algorithm is used to either slow down or speed

up the motor 30 so that the ball is kept on target for stopping at the theoretical final distance. The distance that the ball 11 has travelled can be discerned from the distance markings 15 which are present on the base plate 2 of the device, but in addition the device also displays the distance that the ball has travelled via the LCD unit 60.

5 In addition to simulating different putting green stimp values, the device may also simulate greens having varying contours and undulations. Information concerning the relief of various greens can be stored in the memory device 81 of the computer 84 so that in addition (upon a strike to the ball 11 causing the H-bridge motor drive 82 to control speed and distance of the ball for a particular stimp value), the microcontroller 80 sends
10 control signals to the H-bridge motor drive 82 to accelerate or decelerate the ball further, depending on whether the simulated green slopes downwards or upwards or undulates. Such acceleration/deceleration of the ball can be seen by the user in real time and may be particularly effective for use in situations where the device is used in connection with a video-game or other video-display as described in greater detail below.

15 The device may include means for ensuring that the base plate 2 is horizontal when placed on the ground. Such means may include a number of feet of adjustable length which are provided on the underside of the base plate, and one or more spirit levels mounted on top of the device which indicate whether or not the device is flat.

20 The device may incorporate a metronome which can be employed by a user to practice and improve the timing of their back-swing and stroke. Preferably the metronome can be operated independently of the main device and so can be switched on and off by the user as desired.

As an alternative to battery power, the device may incorporate an appropriate socket for connection to a mains power supply.

The device in accordance with the present invention may be programmed to operate in a games mode in which the device is connected to external equipment 83. For this purpose, the device may comprise a communication port. To facilitate communication of the device with other equipment means of transmitting and/or receiving data to and/or from the other equipment may be provided within the microcontroller 84; for example a universal asynchronous receiver transmitter (UART) may be incorporated into the device, although it will be appreciated that any other suitable communication port can equally be substituted into the device.

The external equipment may comprise a game card that carries information that can be accessed and processed by the microcontroller 80. Alternatively the device may be linked to a games console, personal computer or other electronic game; for example, the device may be used in conjunction with an amusement arcade game. Such a configuration may allow, for example, a player to challenge a famous professional golfer by attempting a "famous putt" made previously by that player. A visual representation of a putting green may be displayed to user via a video display, and the user may then have the opportunity to perform the same putt, with the user's putt being simulated on the video screen. To make such a game as realistic as possible, information regarding the contours of the various greens on which famous putts were played, may be stored in memory and accessible by the microprocessor in order to ensure that the correct acceleration/deceleration of the target is applied.

The training device as hereinbefore described thus measures the initial velocity of a ball following a putt by a user and uses this velocity to calculate the notional distance that an unconstrained ball would have moved on a real putting green having a particular stimp value. The device uses this information to drive the ball to the correct final distance by applying appropriate acceleration or deceleration to the ball in order to ensure that the ball

decelerates at the correct rate. This provides the user with visual feedback of how far and how quickly the ball has travelled. Because a user does not have to alter his stance greatly in order to reset the device and play a subsequent stroke, a user is able rapidly to acquire a feel for an effective putting stroke that can be transferred to the actual game. Additionally,

5 the device can be used in a number of games modes to provide a realistic aspect to a golfing game.

Claims

1. A golf stroke practising aid comprising:

a target adapted to be struck by a golf-club;

guiding means for constraining said target to move in a substantially horizontal

orbit when struck;

measuring means for measuring the initial speed of the target when struck;

processing means configured to determine a notional total distance that the target should travel in its orbit corresponding to said initial speed; and

motion controlling means adapted to control the movement of the target in its orbit when struck such that the target actually moves a total distance which is substantially the same as said notional total distance.

2. A practising aid as claimed in claim 1, wherein said notional total distance is the total distance that a standard golf ball would have travelled freely on a real putting green.

3. A practising aid as claimed in claim 1 or claim 2, wherein said processing means

are adapted to calculate a notional relationship between the instantaneous speed of the target and the elapsed time after striking said target based on said notional total distance,

said measuring means are adapted to measure continually the elapsed time after striking

the target and the actual instantaneous speed of the target as it moves in said orbit, and said

motion controlling means are adapted to compare the actual instantaneous speed with said

notional instantaneous speed and to adjust continually the speed of the target accordingly

to ensure that the target moves about said total distance.

4. A practising aid as claimed in any of claims 1 to 3, wherein said measuring means

comprise a first motion detector which is adapted to generate a first pulsed motion

detection signal in response to movement of the target, the frequency of said first pulsed

signal corresponding to the speed of the target.

5. A practising aid as claimed in claim 4, wherein each pulse corresponds to movement of the target in said orbit by a predetermined increment of distance, said measuring means being adapted to calculate the speed of the target from time between successive pulses.

5 6. A practising aid as claimed in claim 5, wherein said first motion detector comprises a first rotatable part and a first fixed part, the first rotatable part being coupled to the target such that movement of the target in its orbit when struck causes corresponding rotation of said first rotatable part about an axis of rotation relative to the first fixed part, wherein one of said first rotatable and fixed parts comprises a first optical encoder ring which is
10 disposed substantially co-axially with the axis of rotation, and the other of said parts comprises a first photo-emitter and a first photo-detector adapted to detect light emitted by said first photo-emitter, wherein said first optical encoder ring comprises a plurality of regular formations which are circumferentially spaced at substantially equal intervals about said encoder ring to define a plurality of regular gaps therebetween, said first photo-emitter
15 is arranged to direct a beam of light at the first encoder ring, such that the formations intermittently interrupt the beam as the first rotatable part rotates to produce a series of pulses of light; and said first photo-detector is arranged to detect said pulses of light and to generate a corresponding first pulsed motion detection signal in which each pulse corresponds to a pulse of light.

20 7. A practising aid as claimed in claim 4, further comprising direction determining means for determining the direction of movement of the target in its orbit.

8. A practising aid as claimed in claim 7, wherein said direction determining means comprise a second motion detector which is adapted to generate a second pulsed motion detection signal in response to movement of the target, the frequency of said second pulsed
25 signal corresponding to the speed of the target and being substantially the same as the

frequency of the first pulsed signal, and comparing means for comparing the first and signal signals, the phases of the first and second pulsed signals being off-set to allow said comparing means to determine, and said comparing means being configured to determine, the direction of movement of the target by quadrature.

5 9. A practising aid as claimed in claim 6, further comprising a second motion detector comprising a second rotatable part and a second fixed part, the second rotatable part being coupled to the target such that movement of the target in its orbit when struck causes corresponding rotation of said second rotatable part about an axis of rotation relative to the second fixed part, wherein one of said second rotatable and fixed parts comprises a second
10 optical encoder ring which is disposed substantially co-axially with the axis of rotation, and the other of said parts comprises a second photo-emitter and a second photo-detector adapted to detect light emitted by said second photo-emitter, wherein said second optical encoder ring comprises a plurality of regular formations which are circumferentially spaced at substantially equal intervals about said encoder ring to define a plurality of
15 regular gaps therebetween, said second photo-emitter is arranged to direct a beam of light at the second encoder ring, such that the formations intermittently interrupt the beam as the second rotatable part rotates to produce a series of pulses of light; and said second photo-detector is arranged to detect said pulses of light and to generate a corresponding second pulsed motion detection signal in which each pulse corresponds to a pulse of light, the first
20 and second motion detectors being configured and arranged such the frequencies of said first and second pulsed signals are substantially the same, and the phases of the first and second pulsed signals are off-set such that the direction of movement of the target can be determined by quadrature.

10. A practising aid as claimed in claim 8 or claim 9, wherein the phases of said first
25 and second pulsed signals are offset by about 90° .

11. A practising aid as claimed in any preceding claim, wherein said motion controlling means comprise:

a motor which is drivingly coupled to said target for controlling movement thereof;

and

motor controlling means for controlling operation of the motor.

12. A practising aid as claimed in claim 11, wherein said motor controlling means comprise an H-bridge motor drive.

13. A practising aid as claimed in any preceding claim, further comprising restoring means for restoring the target to a home position.

14. A practising aid as claimed in claim 9, wherein one of said first and second optical encoder rings comprises a home formation having a unique size or spacing as compared with the other formations on said one ring for allowing the rotational orientation of the respective rotatable part, and thus the rotational orientation of the target, to be determined.

15. A practising aid as claimed in claim 14, wherein said home formation is configured so as to alter transiently the phase off-set between said first and second motion detection signals when the target is at its home position.

16. A practising aid as claimed in claim 15, wherein said respective rotatable part is arranged such that said home finger is disposed adjacent the respective photo-emitter and photo-detector when the target is in the home position.

17. A practising aid as claimed in claim 16, further comprising home restoring means which are adapted to generate a home restoration signal for controlling said motion controlling means to move the target at a constant speed in its orbit, and to analyse the pulsed motion detection signals generated by the respective motion detectors for determining when the home finger is disposed adjacent the respective photo-emitter and

photo-detector, said home restoring means being configured to control the motion
controlling means then to halt so that the target is positioned at the home position.

18. A practising aid as claimed in any of claims 6 to 17, wherein said guiding means
comprise a or substantially rigid arm, said target being mounted on one end of the arm and
5 the other end of the arm being secured to one of said first and second rotatable parts.

19. A practising aid as claimed in any preceding claim, wherein said target comprises a
standard golf ball.

20. A practising aid as claimed in any preceding claim, further comprising display
means for receiving and displaying information to a user.

10 21. A practising aid as claimed in any preceding claim, further comprising
communication means for transmitting data to and/or receiving data from external
equipment.

22. A practising aid as claimed in any preceding claim further comprising user input
means for manually selecting of one or more parameters of operation of the practising aid.

15 23. A practising aid as substantially hereinbefore described and with reference to and
as shown in FIGS. 1 to 10 of the accompanying drawings.

24. A golf stroke training device comprising:

a supporting structure which is adapted to stand stably on the ground in use;

a rotator defining an axis of rotation, said rotator being rotatably mounted to said
20 supporting structure such that said axis of rotation extends substantially vertically when the
supporting structure stands on the ground, said rotator being adapted for rotation about said
axis;

a rigid or substantially rigid arm having an inner end and an outer end, said inner
end being connected to said rotator, said arm being arranged such that said outer end is
25 adapted to rotate in a substantially horizontal plane upon rotation of the rotator;

a target adapted to be struck by a golf-club, said target being joined to said outer end of said arm, such that when the target is struck by a golf-club, the target is caused to rotate about said axis of rotation in a substantially horizontal orbit;

a first optical encoder ring mounted on said rotator for rotation therewith, said first
5 optical encoder ring comprising a plurality of regular formations which are circumferentially spaced about said axis of rotation at substantially equal intervals, said ring having a first inner side and a second outer side;

a first photo-emitter adapted to emit a beam of light, and a first photo-detector adapted to detect light emitted by said first photo-emitter, said first photo-emitter and first
10 photo-detector being fixedly mounted to said supporting structure on opposite sides of said first optical encoder ring, such that said beam is directed across the formations of the first optical encoder ring towards said first photo-detector, such that said formations interrupt the beam intermittently as the rotator rotates to produce a series of pulses of light, which pulses of light are detected by said photo-detector to produce a first pulsed motion
15 detection signal, whereby the time between successive pulses of said pulsed motion detection signal is proportional to the speed of said target;

a motor which is mounted to said supporting structure and drivably coupled to the rotator for adjusting the speed of the rotator;

a motor controller for controlling the motor; and

20 a microcontroller having an input which is adapted to receive said first motion detection signal, a clock configured to provide a constant measure of time, a microprocessor adapted continually to process said first motion detection signal to determine the actual instantaneous speed of the target, said microprocessor being programmed to detect when the target is struck and to calculate the initial speed of said

25 target, a memory device storing distance information relating a total notional distance to be

travelled by the target to said initial speed, said microprocessor being programmed for determining from said initial speed and said distance information a particular notional total distance to be travelled by said target and for determining from said particular total notional distance a relationship between the notional instantaneous speed of the target and the time elapsed since the target was struck, said microprocessor being further programmed to compare continually the actual instantaneous speed of the target with said notional instantaneous speed to generate a velocity error value, and to generate a motor control signal corresponding to said velocity error value, and an output adapted for outputting said motor control signal to said motor controller for controlling the motor to adjust the actual instantaneous speed of the target to said notional instantaneous speed, such that the actual total distance travelled by said target in its orbit is substantially the same as said particular notional total distance.

25. A training device as claimed in claim 24, wherein said memory device stores a plurality of different, predetermined, user-selectable values of notional resistance to rotation of the rotator, and stores distance information for each value of notional resistance relating the total notional distance to be travelled by the target to said initial speed, said microcontroller further comprises a user-selection input component which is adapted to enable a user to select a desired one of said predetermined values.

26. A training device as claimed in claim 24 or claim 25, further comprising:

a second optical encoder ring mounted to the rotator for rotation therewith, said second optical encoder ring being arranged substantially coaxially with said first optical encoder ring, and comprising a plurality of regular formations which are circumferentially spaced about said axis of rotation at substantially equal intervals, said ring having a first inner side and a second outer side;

a second photo-emitter adapted to emit a beam of light, and a second photo-detector adapted to detect light emitted by said second photo-emitter, said second photo-emitter and second photo-detector being fixedly mounted to said supporting structure on opposite sides of said second optical encoder ring, such that said beam is directed across the formations of said second optical encoder ring, such that said formations can interrupt said beam
5 intermittently as the rotator rotates to produce a series of pulses of light, which pulses of light are detected by said photo-detector to produce a second pulsed motion detection signal;

said first and second optical encoder rings, said first and second photo-emitters and
10 said first and second photo-detectors being configured and arranged such the frequencies of said first and second pulsed signals are substantially the same, and the phases of the first and second pulsed signals are off-set ;

wherein said input is further adapted to receive said second motion detection signal, and said microprocessor is further programmed to compare said second motion detection
15 signal with said first motion detection signal to determine the direction of rotation of the rotator by quadrature.

27. A training device as claimed in claim 24, claim 25 or claim 26, wherein said motor controller comprises an H-bridge motor drive.

28. A device as claimed in claim 26, wherein one of said first and second optical
20 encoder rings comprises a home formation of unique size or unique spacing as compared with the other formations on said one optical encoder ring, said home formation being positioned on said one encoder ring such that said home formation is positioned adjacent the respective photo-emitter and photo-detector when the target is in a home position; and

said microprocessor is programmed with a selectively operable home restoration
25 routine, which home restoration routine comprises outputting appropriate motor control

signals for controlling said motor to drive said rotator at a constant angular velocity whilst processing the respective motion detection signal to detect the home formation, and when said home formation is detected ceasing output of said motor control signals to halt operation of the motor, thereby bringing said rotator to rest at the home position.

29. A training device as claimed in any of claims 24 to 28, wherein said target comprises a standard golf ball.

30. A training device as claimed in any of claims 24 to 29, further comprising a display device for receiving and displaying information to a user.

31. A device as claimed in any of claims 24 to 30, further comprising a communication device for transmitting data to and/or receiving data from external computer equipment.

32. A putting practising aid comprising:

a stationary support;

a rotator mounted to the stationary support and adapted for rotation about a substantially vertical axis;

a target mounted to said rotator for rotation about said axis in a substantially horizontal orbit, said target being adapted to be struck by a golf putter; and

motion controlling means for controlling rotation of said rotator by applying a predetermined resistance to movement of the target to simulate the feel of putting a golf ball on a real green.

33. A putting practising aid as claimed in claim 32, wherein said motion controlling means are configured to apply selectively a plurality of different, predetermined, user-selectable values of resistance to rotation of the rotator, and means are provided to enable a user to select a desired one of said predetermined values.

34. A putting practising aid as claimed in claim 32 or claim 33, wherein said motion controlling means comprise a motor drivably connected to said rotator.

35. A putting practising aid as claimed in claim 33 or claim 34 wherein said motion controlling means comprise means for measuring the initial velocity of the rotator, clock means for measuring the time elapsed from striking the target, means for calculating a notional total distance to be travelled from said initial velocity and said value of resistance to rotation, means for calculating a notional relationship between notional instantaneous speed of said rotator and elapsed time after striking from said notional total distance to be travelled, means for continually measuring the actual instantaneous speed of the rotator at predetermined elapsed times after the target is struck, speed comparing means for comparing the actual instantaneous speed of the rotator at each elapsed time with the notional instantaneous speed, and means for adjusting the speed of the rotator as necessary to the notional instantaneous speed.

36. A putting practising aid as claimed in claim 35, wherein said motion controlling means comprise a first motion detector which is adapted to generate a first pulsed motion signal in response to rotation of the target, the frequency of said first pulsed signal corresponding to the speed of the target.

37. A practising aid as claimed in claim 36, wherein each pulse corresponds to movement of the target in said orbit by a predetermined increment of distance, said measuring means being adapted to calculate the speed of the target from time between successive pulses and the size said increment

38. A putting practising aid as claimed in claim 36 or claim 37, wherein said first motion detector comprises a first rotatable part and a first fixed part, the first rotatable part being coupled to the rotator such that movement of the target in its orbit when struck causes corresponding rotation of said first rotatable part relative to the first fixed part, wherein one of said first rotatable and fixed parts comprises a first optical encoder ring, and the other of said parts comprises a first photo-emitter and a first photo-detector adapted

to detect light emitted by said first photo-emitter, wherein said first optical encoder ring comprises a plurality of regular formations which are circumferentially spaced at substantially equal intervals about said encoder ring to define a plurality of regular gaps therebetween, said first photo-emitter is arranged to direct a beam of light at the first encoder ring, such that the formations intermittently interrupt the beam as the first rotatable
5 part rotates to produce a series of pulses of light; and said first photo-detector is arranged to detect said pulses of light and to generate a corresponding first pulsed motion detection signal in which each pulse corresponds to a pulse of light.

39. A putting practising aid as claimed in any of claims 36 to 38, further comprising
10 direction determining means for determining the direction of rotation of the target.

40. A putting practising aid as claimed in claim 39, wherein said direction determining means comprise a second motion detector which is adapted to generate a second pulsed motion signal in response to movement of the target, the frequency of said second pulsed signal corresponding to the speed of the target and being substantially the same as the
15 frequency of the first pulsed signal, and signal comparing means for comparing the first and second signals, the phases of said first and second pulsed signals being mutually offset to allow said comparing means to determine, and said signal comparing means being programmed to determine the direction of movement of the target by quadrature.

41. A practising aid as claimed in claim 38, further comprising a second motion
20 detector comprising a second rotatable part and a second fixed part, the second rotatable part being coupled to the rotator such that rotation of the target when struck causes corresponding rotation of said second rotatable part relative to the second fixed part, wherein one of said second rotatable and fixed parts comprises a second optical encoder ring, and the other of said parts comprises a second photo-emitter and a second photo-
25 detector adapted to detect light emitted by said second photo-emitter, wherein said second

optical encoder ring comprises a plurality of regular formations which are circumferentially spaced at substantially equal intervals about said encoder ring to define a plurality of regular gaps therebetween, said second photo-emitter is arranged to direct a beam of light at the second encoder ring, such that the formations intermittently interrupt the beam as the second rotatable part rotates to produce a series of pulses of light; and said second photo-detector is arranged to detect said pulses of light and to generate a corresponding second pulsed motion detection signal in which each pulse corresponds to a pulse of light, the first and second motion detectors being configured and arranged such the frequencies of said first and second pulsed signals are substantially the same, and the phases of the first and second pulsed signals are off-set such that the direction of movement of the target can be determined by quadrature.

42. A putting practising aid as claimed in claim 40 or claim 41, wherein the phases or said first and second pulsed signals are mutually offset by about 90° .

43. A putting practising aid as claimed in claim 34, wherein said motion controlling means further comprise motor controlling means for controlling operation of the motor.

44. A putting practising aid as claimed in claim 43, wherein said motor controlling means comprise an H-bridge motor drive.

45. A putting practising aid as claimed in any of claims 32 to 44, further comprising restoring means for restoring the target to a home position.

46. A putting practising aid as claimed in claim 41, wherein one of said first and second optical encoder rings comprises a home formation having a unique size or spacing as compared with the other formations on said one ring for allowing the rotational orientation of the respective rotatable part, and thus the rotational orientation of the target, to be determined.

47. A putting practising aid as claimed in claim 46, wherein said respective rotatable part is arranged such that said home finger is disposed adjacent the respective photo-emitter and photo-detector when the target is in the home position.

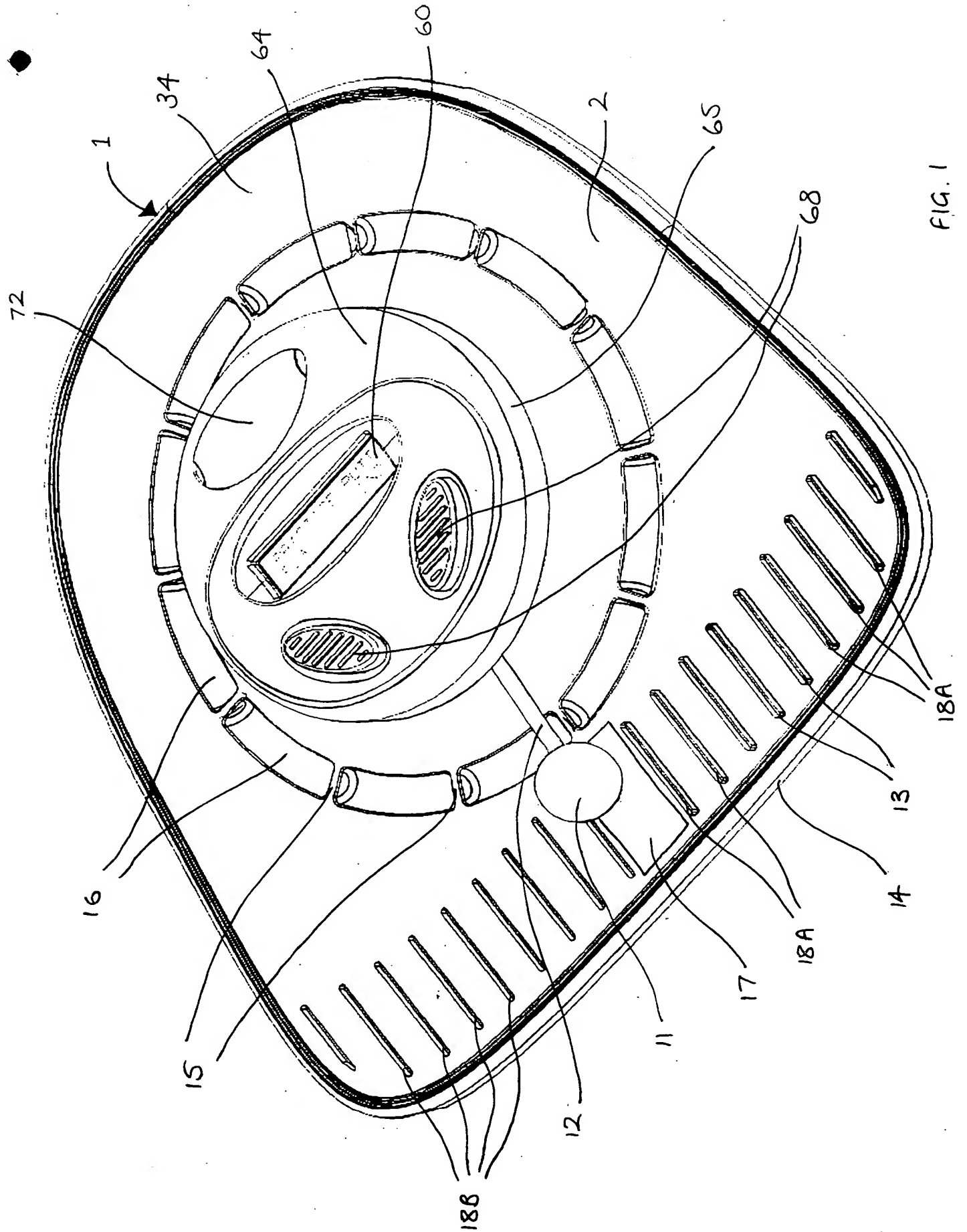
48. A putting practising aid as claimed in claim 47, further comprising home restoring means which are adapted to generate a home restoration signal for controlling said motion controlling means to rotate the target at a constant speed, and to analyse the pulsed signal generated by the respective motion detector for determining when the home finger is disposed adjacent the respective photo-emitter and second photo-detector, said home restoring means being configured to control the motion controlling means then to halt so that the target is positioned at the home position.

49. A putting practising aid as claimed in any of claims 32 to 48, wherein said target is connected to said rotator by a rigid or substantially rigid arm.

50. A putting practising aid as claimed in any of claims 32 to 49, wherein said target comprises a standard golf ball.

51. A putting practising aid as claimed in any of claims 32 to 50, further comprising display means for receiving and displaying information to a user.

52. A putting practising aid as claimed in any of claims 32 to 51, further comprising communication means for transmitting data to and/or receiving data from external equipment.



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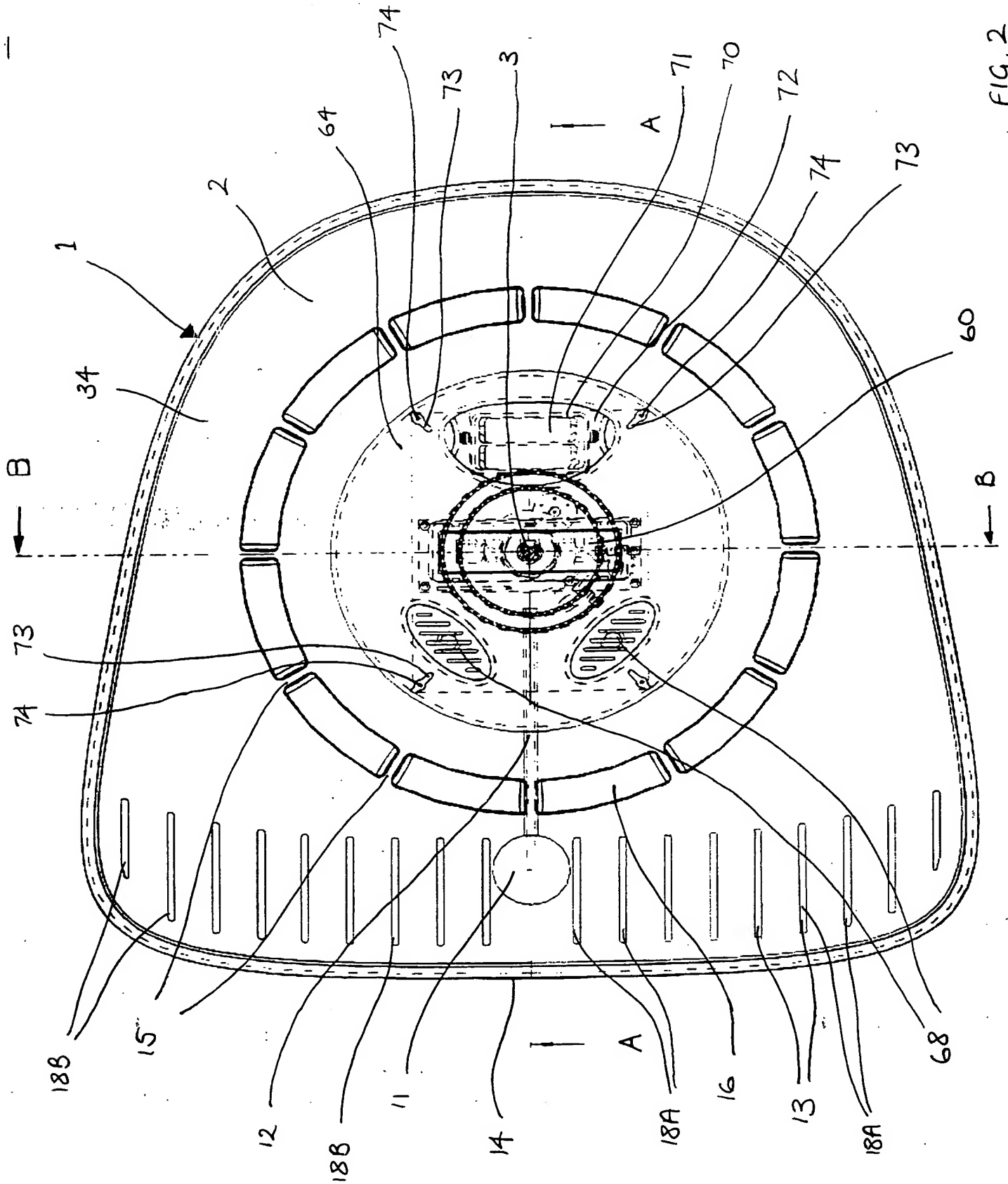


FIG. 2

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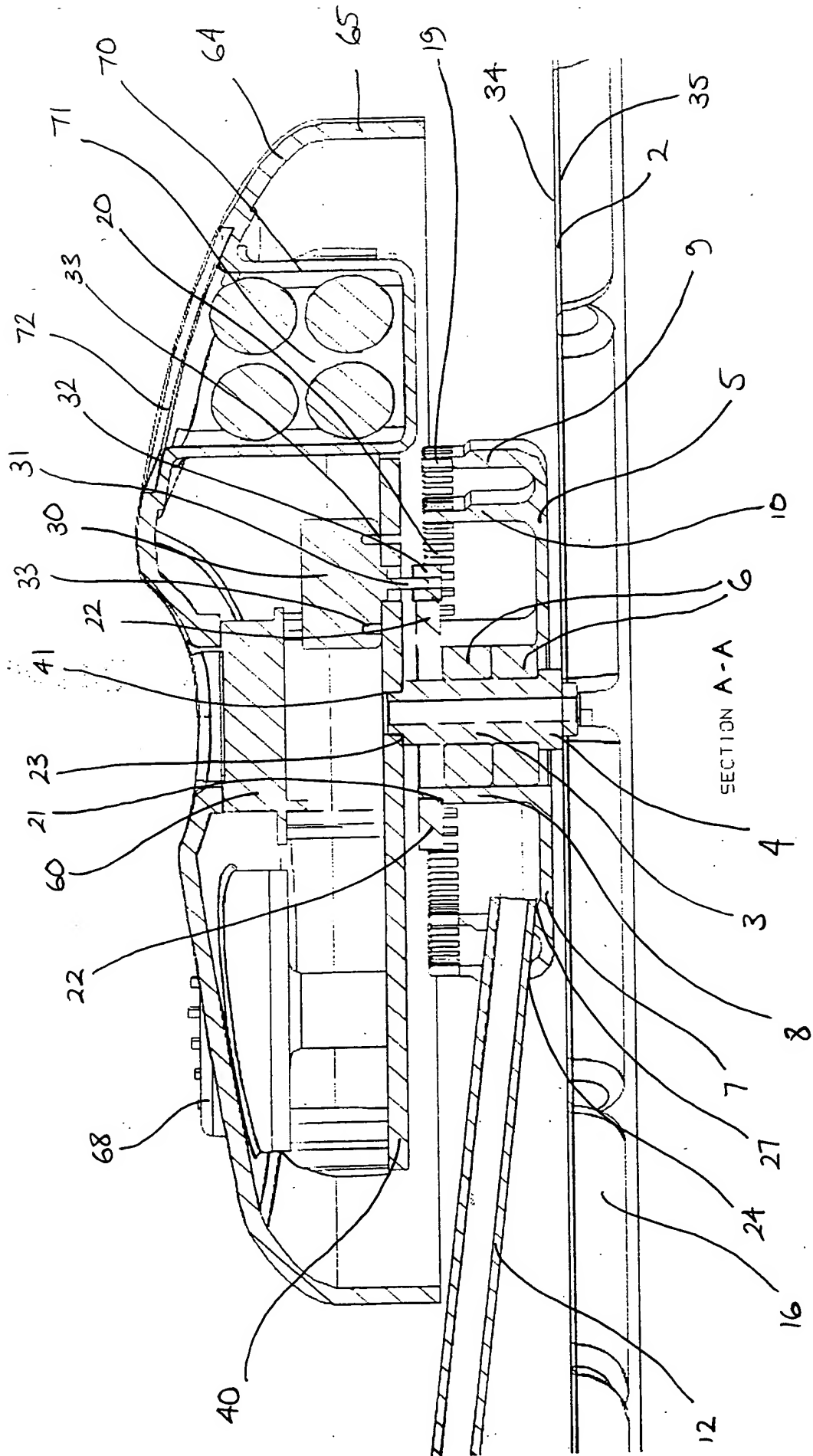


FIG. 3

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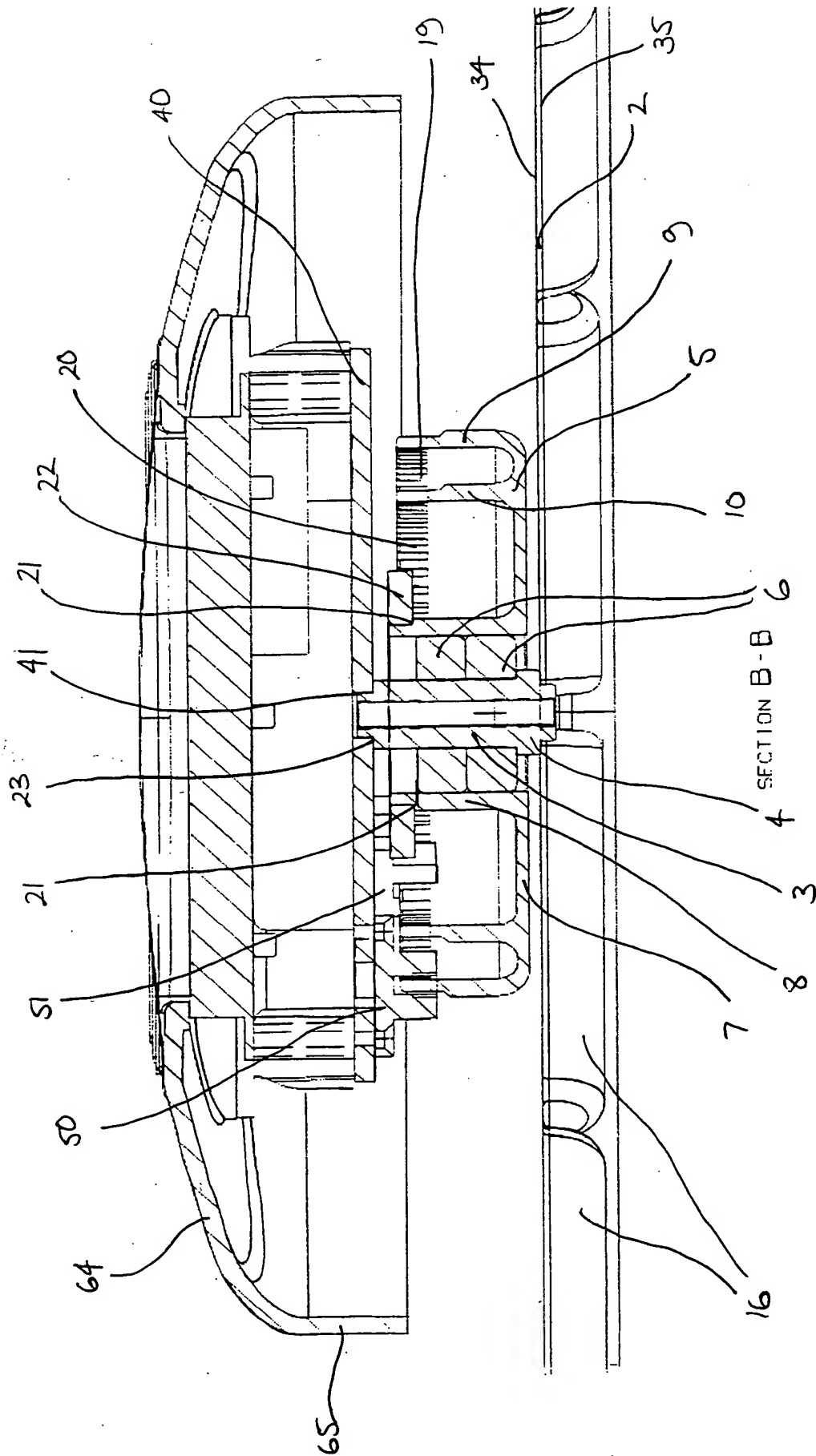


FIG. 4

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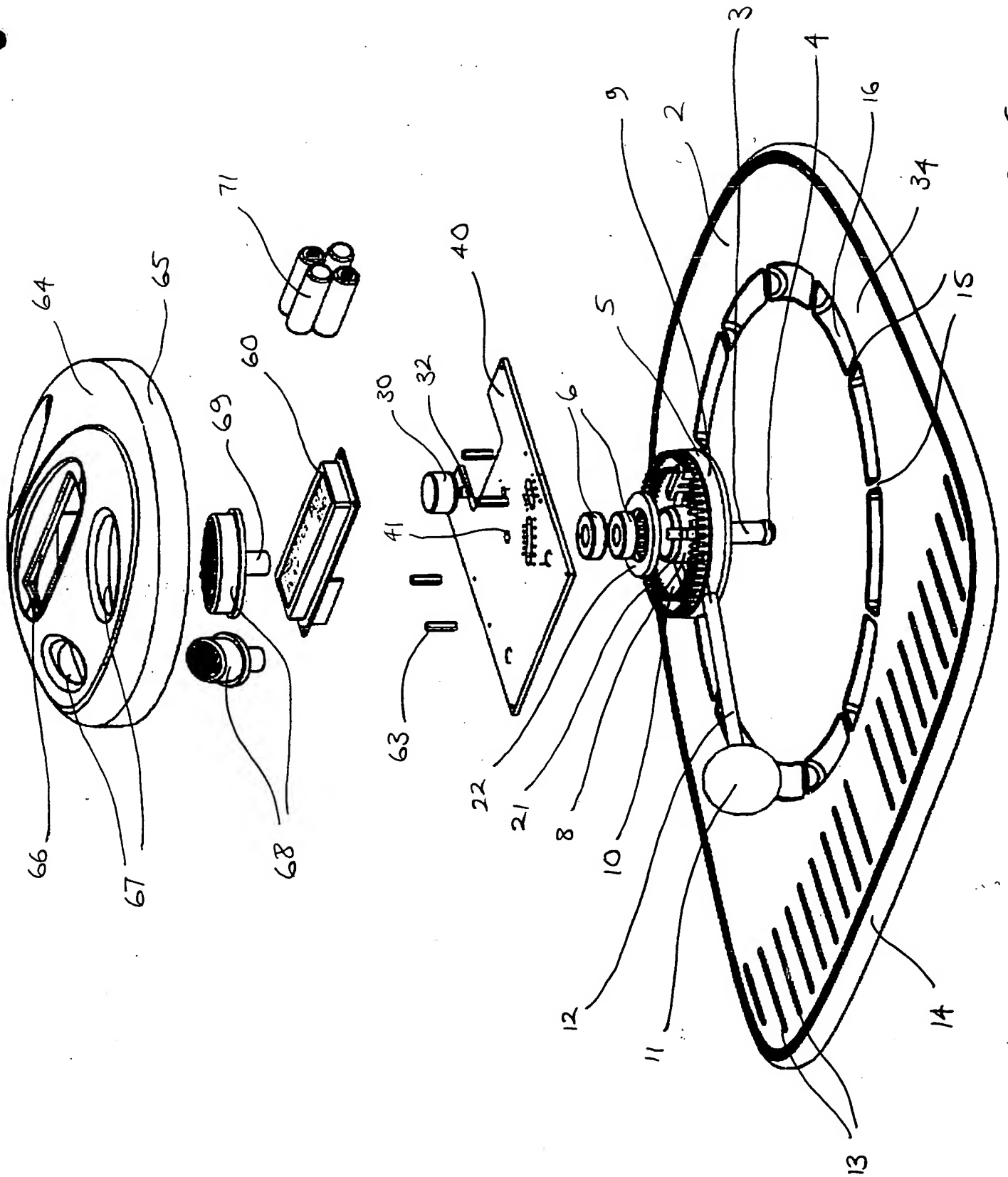


FIG. 5

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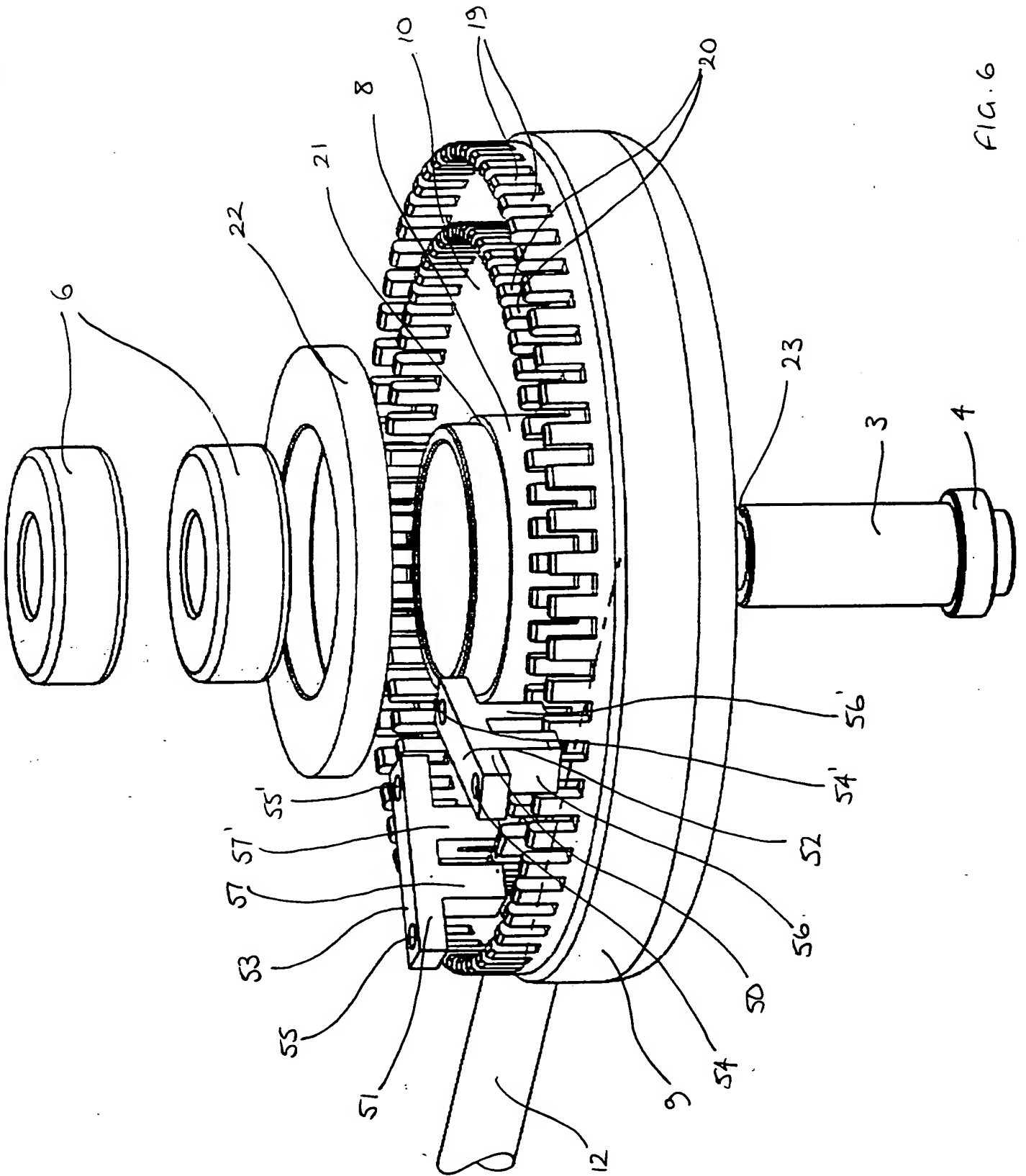


FIG. 6

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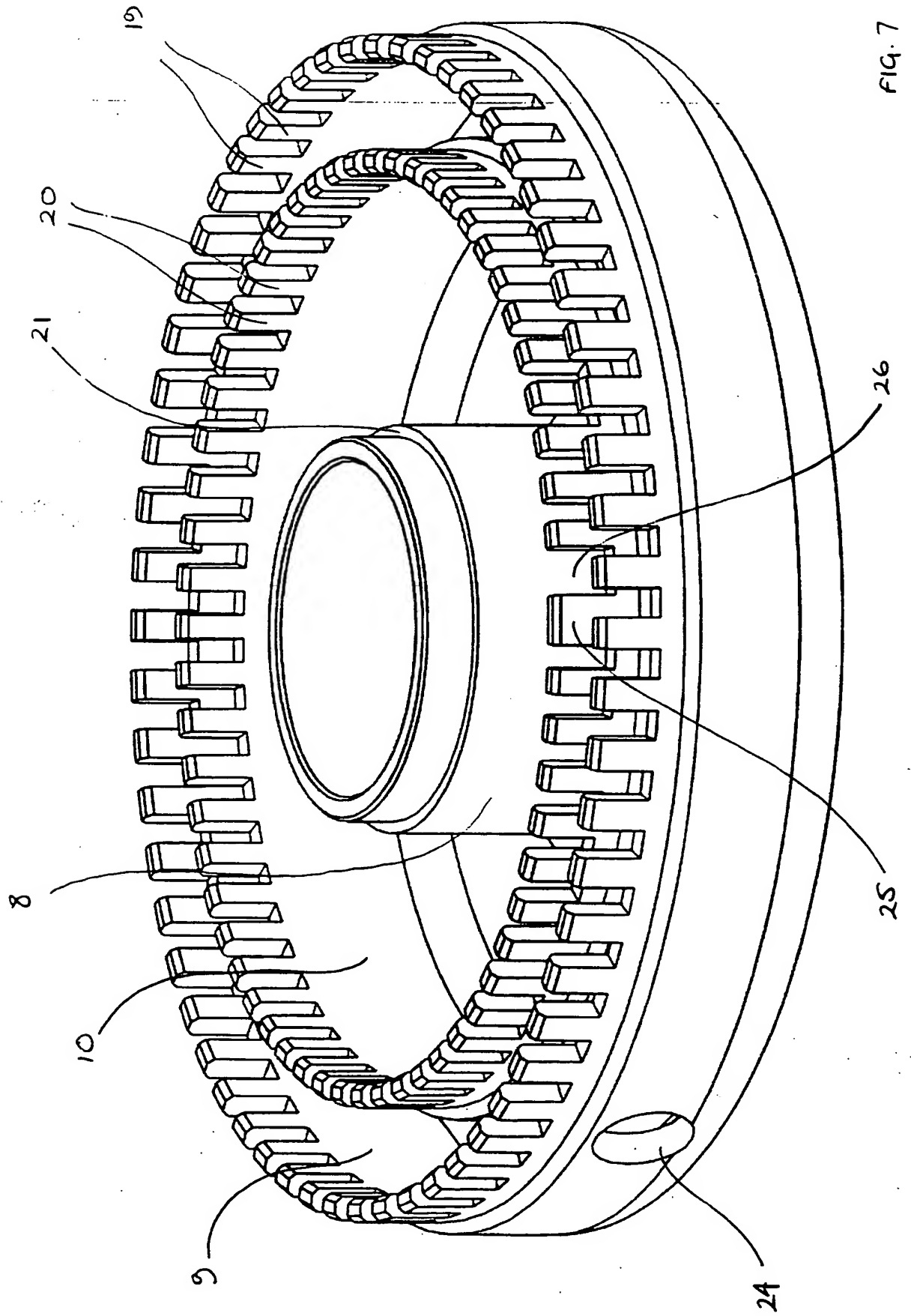
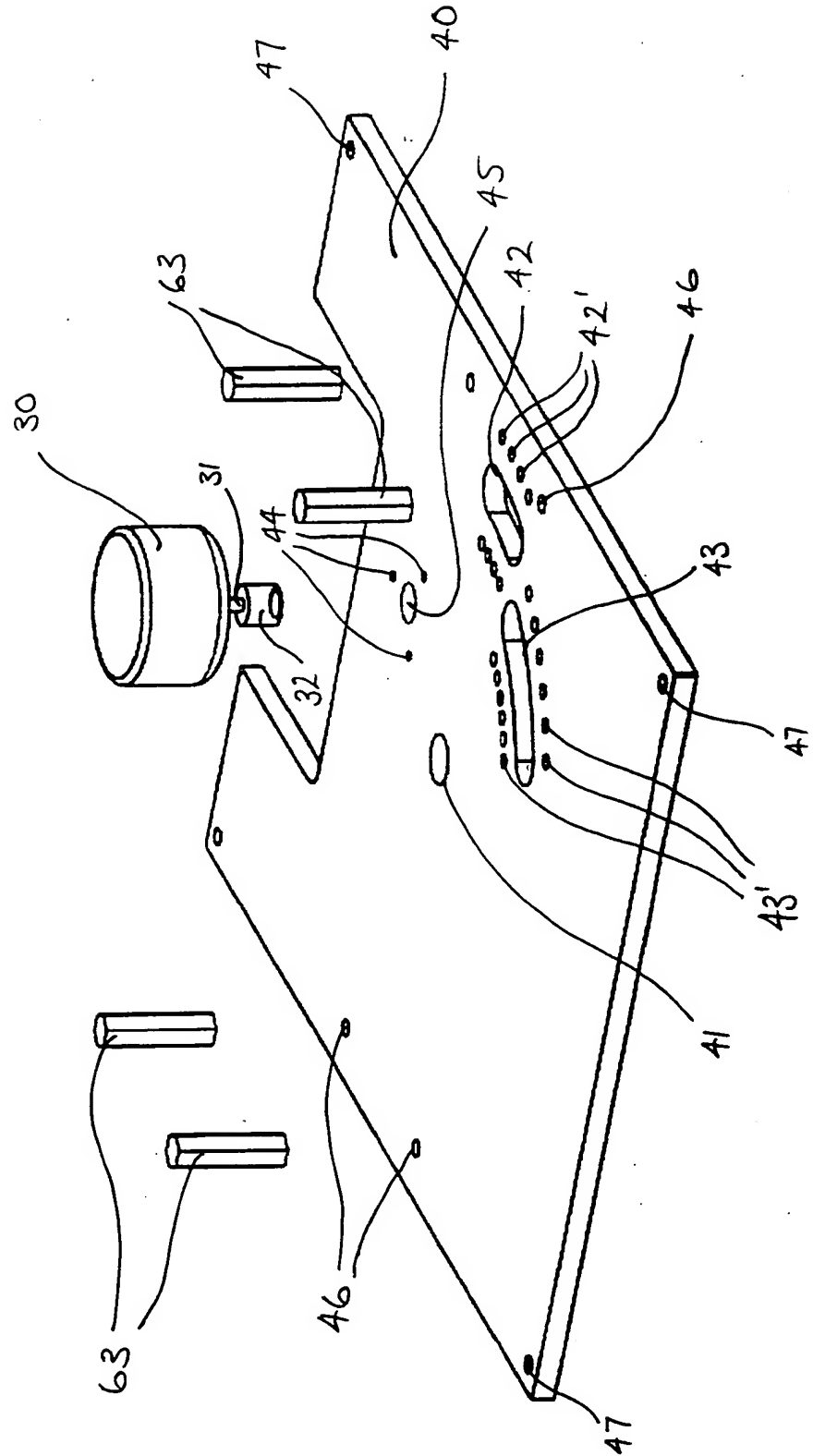
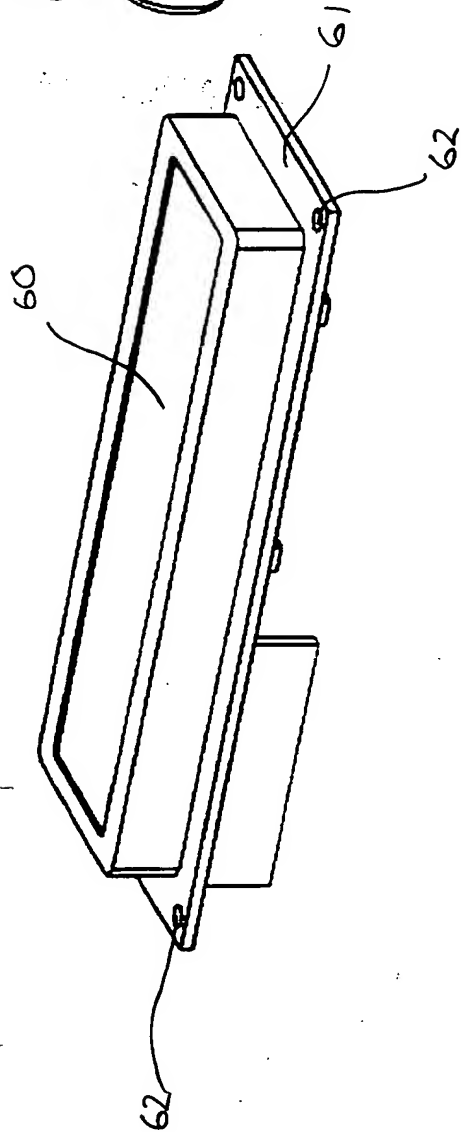
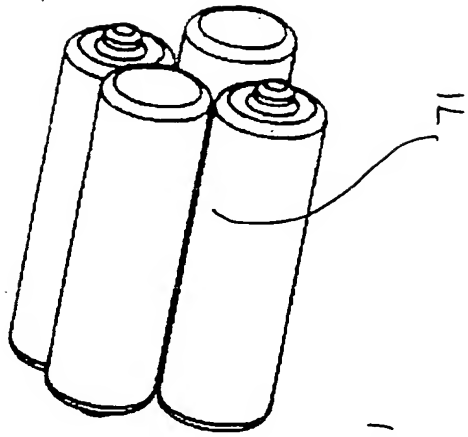


FIG. 7

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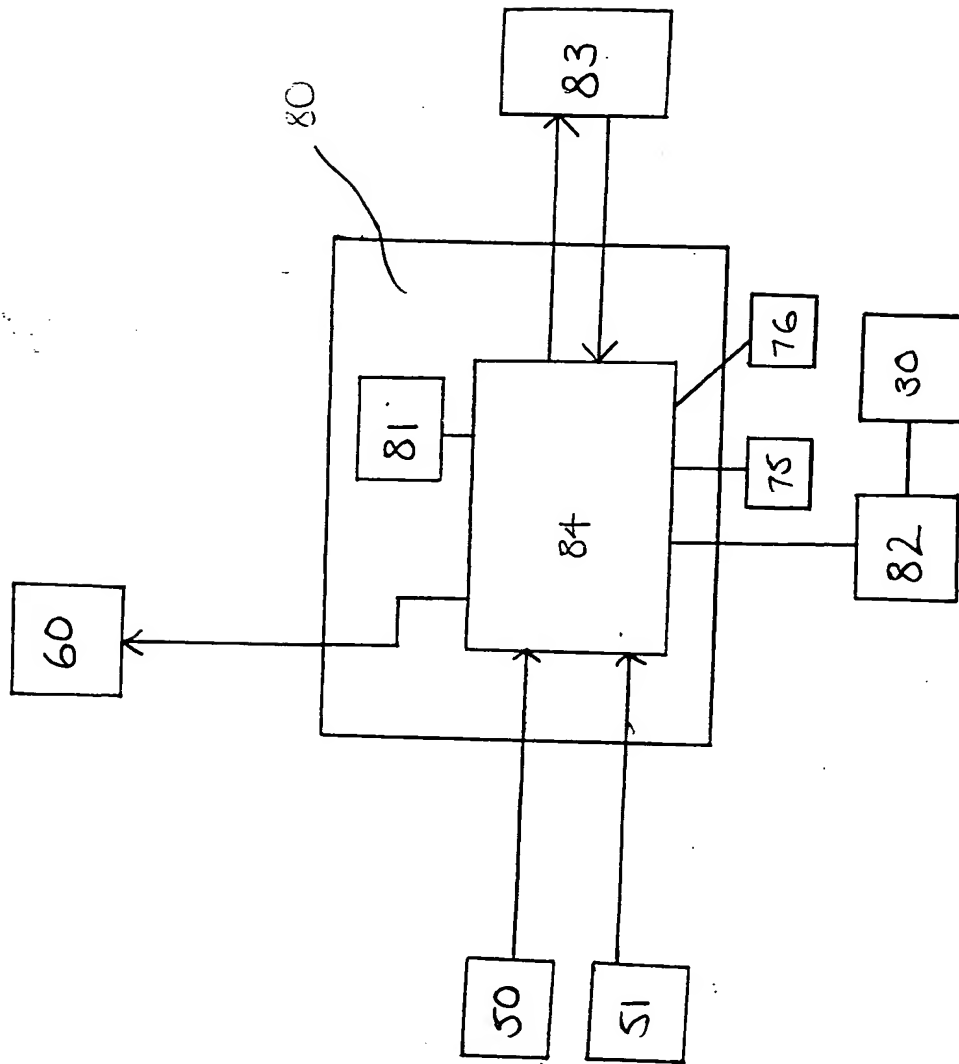


FIG. 9

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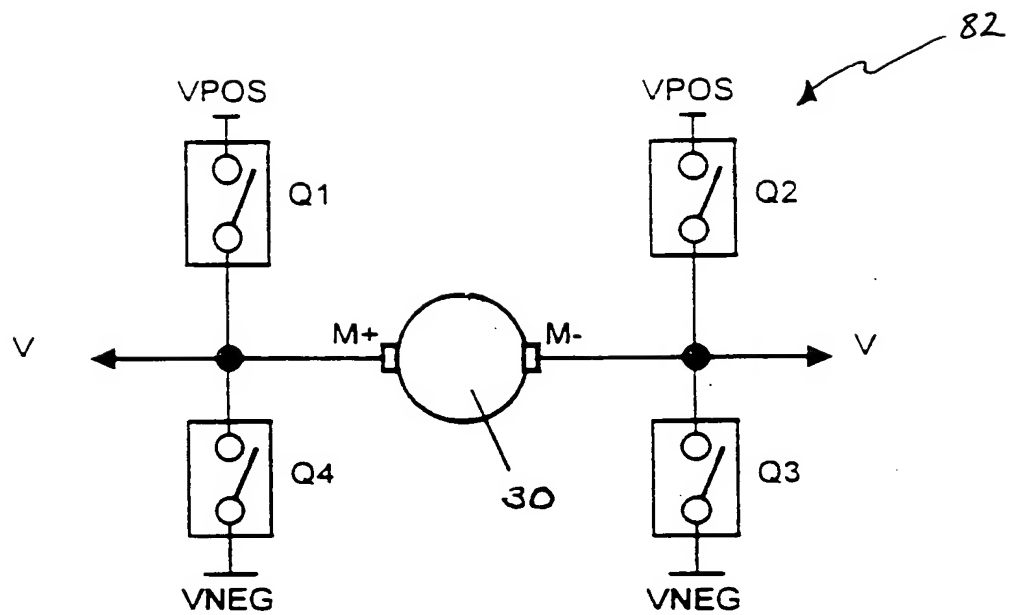


FIG. 10

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